Dissertation Report

On

"SMART METERING - CONCERN, CHALLENGES, & BENEFITS IN INDIAN CONTEXT"

A report submitted in partial fulfillment of the requirement of dissertation for

MASTER OF BUSINESS ADMINISTRATION
(POWER MANAGEMENT)

UNDER THE GUIDANCE OF:

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DECLARATION

I, **YASHASWI GYANPURI,** Enrollment No. R130213060, student of MBA-Power Management (2013-15) at University of Petroleum & Energy Studies, Dehradun hereby declare that the Dissertation Report entitled

"Smart Metering- Concern, Challenges & Benefit in Indian Context"

is an original work and the same has not been submitted to any other institute for the award of any other degree.

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Yashaswi Gyanpuri

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EXECUTIVE SUMMARY

Indian power sector faces 8-10% peak demand shortage. Adding capacity alone cannot meet the rising consumer demand sustainably. Optimum and efficient use of energy is the need of the hour, and Narendra Modi government is more stringent & focused on it. With the intention of sustainable use of resources and to maintain grid stability countries across have found a viable solution in the form of smart grid and an urgent need to adopt. Smart grid is an intelligent future electricity system that connects all supply, grid and demand elements through a communication system to facilitate efficient use of the grid to identify and correct supply- demand imbalances.

Use of smart meters and deployment of Advanced Metering Infrastructure (AMI) is one among several components of to move towards smart grid. Smart meter technology is a key component of the AMI that will help the smart grid link the two-way flow of electricity with the two-way flow of information.

Beneficial uses of Smart Metering are many. Smart meters will permit utilities to collect, measure, and analyze energy consumption data for grid management, outage notification, and billing purposes. The meters will contribute towards optimum energy usage by giving consumers greater control over their use of electricity, besides permitting integration of plug-in electric vehicles and renewable energy sources. They may also aid in the development of a more reliable electricity grid that is better equipped to withstand cyber-attacks and natural disasters, and help to decrease peak demand for electricity developing rapidly.

Privacy and security concerns surrounding smart meter technology arise from the meters‘ essential functions, which include (1) recording near-real time data on consumer electricity usage; (2) transmitting this data to the smart grid using a variety of communications technologies; and (3) receiving communications from the smart grid, such as real-time energy prices or remote commands that can alter a consumer‘s electricity usage to facilitate demand response.

To be useful for these purposes, and many others, data recorded by smart meters must be highly detailed, and, consequently, it may show what individual appliances a consumer is using. The data must also be transmitted to electric utilities—and possibly to third parties outside of the smart grid—subjecting it to potential interception or theft as it travels over communications networks and is stored in a variety of physical locations.

These characteristics of smart meter data present privacy and security concerns that are likely to become more prevalent as rollout of initiatives expand deployment of the meters to millions of homes across the country. Installation of smart meters and the communications technologies that accompany them may lead to unforeseen legal consequences for those who generate, seek, or use the data recorded by the meters.

Internationally, smart meter deployment is happening at a fast pace in U.S.A, U.K, China, Korea, Japan etc. Various International experiences have been cited in this report and inferences have been drawn for implement in India.

Smart meters with their inherent features can prove to be a panacea for the distribution sector‘s problems of commercial losses. Keeping this in view, smart meter deployment in India is high on agenda of Smart Grid Task Force. Planning on this front is taking place with government showing keen interest in development of the concept.

However, with the present and persistent status of the distribution sector in India, deployment would not be an easy case. Firstly development of regulatory provisions and standards for the smart meter system are essential which are not present in India. Also, ToU tariff structure, not in place for domestic consumers in India, is at the heart of smart metering scheme. Factors as arrangement of finances for the project, customer education, protection of consumer interest, cost benefit analysis, security, etc. all pose to be challenges for development of the concept in India.

The report covers Smart meter concept, benefits to different stakeholders, Challenges and barriers to implement in India along with the market landscape of smart meter in India in depth. Suggestions/recommendation on regulatory provisions and other factors to move ahead in the domain has been included in the report.

I. Problem Statement

Today, India has one of the highest Transmission and distribution losses in the world- to the tune of 27% and for some states it goes beyond 50% (Source: CEA,2013). One of the primary reasons for such T&D losses is lack of proper accounting of electricity consumption at various steps. With smart metering some of private distribution company have already manage to come down T&D losses upto 10%.

II. Objective

The objectives of this report are:

- ✓ Review the current scenario of metering in India.
- ✓ Study of Smart Metering Technology and its viability in India context.
- ✓ Also evaluates emerging technologies and best practices as well as identify gaps in existing solutions.
- ✓ Regulatory framework for facilitating the Smart Metering in power sector.

III. Scope of the project

1. To study about the Smart meter features with special reference to implement in transmission and distribution sectors.
2. To develop a broad view about the different technologies used in Smart Metering.
3. To develop a broad view about the initiatives taken in India and also the various Pilot Projects running in India.
4. To find suggestive measures to use Smart Meter in India on a large scale and to get maximum benefit out of it.
5. Review the best practice/learning's in smart metering internationally.
6. To find the major challenges, risk and benefit associated in implementation of smart meter in India.

IV. Research Methodology

The research work carried out for this project was more of descriptive in nature. Since this project is a study project, hence in this project the major task was collection of data, and analyzing this data and also studying impact of smart metering in Distribution Sector.

- Study and analysis of reports on Smart metering

- Search for Data and reports available.
- Proper sorting and alignment of appropriate data and reports.
- Collecting all the reports.
- Prepare a framework for Smart Metering.
- Study about the Smart meter implementation in Power Sector.
- Analyze the Smart Metering framework along with case study of Delhi.
- Formulate the international experiences/best practice/learning in India context.

The study is also try to carry out primary research where by the interview of designated concerned authority would be taken for study and analysis.

Review of Terms of References: - Documents containing terms of reference for working on smart metering technologies developed by Working Group 4 of India Smart Grid Forum was studied and various aspects of these terms were discussed at length to get deep insight on the work that is intended to be done in this field.

Review of Indian power sector- Considering the status of utilities, role of regulators, political scenario and socio economic conditions recommendations for deployment in India have been put forth.

Review of International Experiences: - Some case studies relating to deployment of smart meters internationally was studied and understood for better understanding of the problem and coming to an appropriate conclusion. International good practices that may be adopted have also been included from an Indian perspective.

Working Group Meetings: - Various meetings organized by working groups to discuss technical and commercial aspect of the smart metering in India were attended to get better insight on the current Indian scenario on metering technologies and point of view of different stakeholders in smart grid initiative being taken up in India.

Chapter 1

1. INTRODUCTION

From electromechanical meters to electronic meters to AMR (Automated Meter Reading) and prepaid meters to smart meters, the metering industry has embraced evolving information and communication technology for bringing along a revolution in utility operations. With the advent of an Advanced Metering Infrastructure (AMI), both consumers and the utilities would benefit. The consumers would be able to:

- View their consumption of electricity accurately on a regular basis.
- Manage loads in different manners based on the design, ranging from remotely turn ON/OFF their appliances to managing total demand to allow curtailed supply instead of load-shedding.
- Save money from Time of Use (ToU) tariffs by shifting non-priority loads.
- Face reduced outages and downtimes, and even lower or zero load-shedding.

Utilities would benefit in the following ways (which would pass on to the consumer):

a. Financial gains by

i. Managing the load curve by introducing ToU/ToD tariff, demand response etc.

ii. Reducing equipment failure rates and maintenance costs

iii. Enabling faster restoration of electricity service after fault/events

iv. Detecting energy theft/pilferage on near real-time basis

v. Streamlining the billing process

vi. Remote meter reading which reduces human resources, human errors and time consumption for meter reads

b. Respond to power outages and detect meter failures (with no on-site meter reading)

c. Enhanced monitoring of the system resources that would significantly improve the reliability.

d. Improvement in other key performance indicators

1.1. What is Smart Meter?

Smart Meters are new electric, gas, and water digital meters that send usage information via radiofrequency electromagnetic radiation (RF) to a utility company. They are primarily called AMI (advanced metering infrastructure) or AMR (automated meter reading) meters.

Smart Meters can also be wired. The meters collect our energy usage information in very detailed format and transmit that information directly to the utility company every day, throughout the day. Most electric meters use a mesh network system in which the meters relay the energy information from meter to meter until it arrives at a collector meter, which then sends the information on to an antenna, usually mounted on a utility pole. From there, it is transmitted to the utility company. Wired Smart Meters send the usage data via electrical lines or telephone lines (OFC).

Figure 1 How smart metering works

1.2 Drivers of Smart Meter

The drivers for smart metering are many folds, including, reduction in meter reading and revenue realization cycle, identification of fraudulent practice and necessary correction, reduction of peak demand through systematic load reduction, better customer services, assistance in reduction in grid failure and so on.

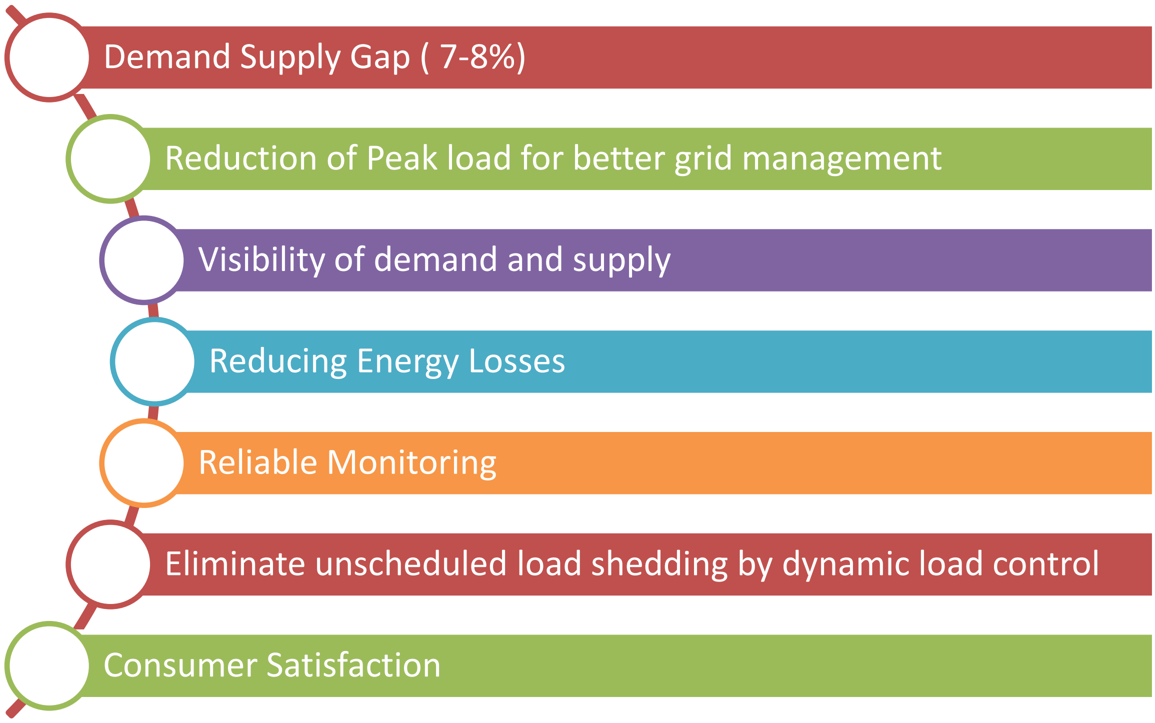


Figure 2 Drivers of Smart Metering

1.3 Conventional Meters and Smart Meter

The basic difference between conventional meters and smart meters is that conventional meters provide one-way of communication whereas smart meters provide two-way communication. For instance, in order to carry out a meter reading using a conventional meter, the meter reader needs to physically visit the customer premise and take reading. This reading will be sent to the utility company for billing. But in case of smart meters, this can be done automatically. The system operator will create a meter read request from the utility company office. The smart meter sends the meter reading as per the request to the utility company. This avoids manual intervention during meter reading and provides more accurate, real-time data to the company.

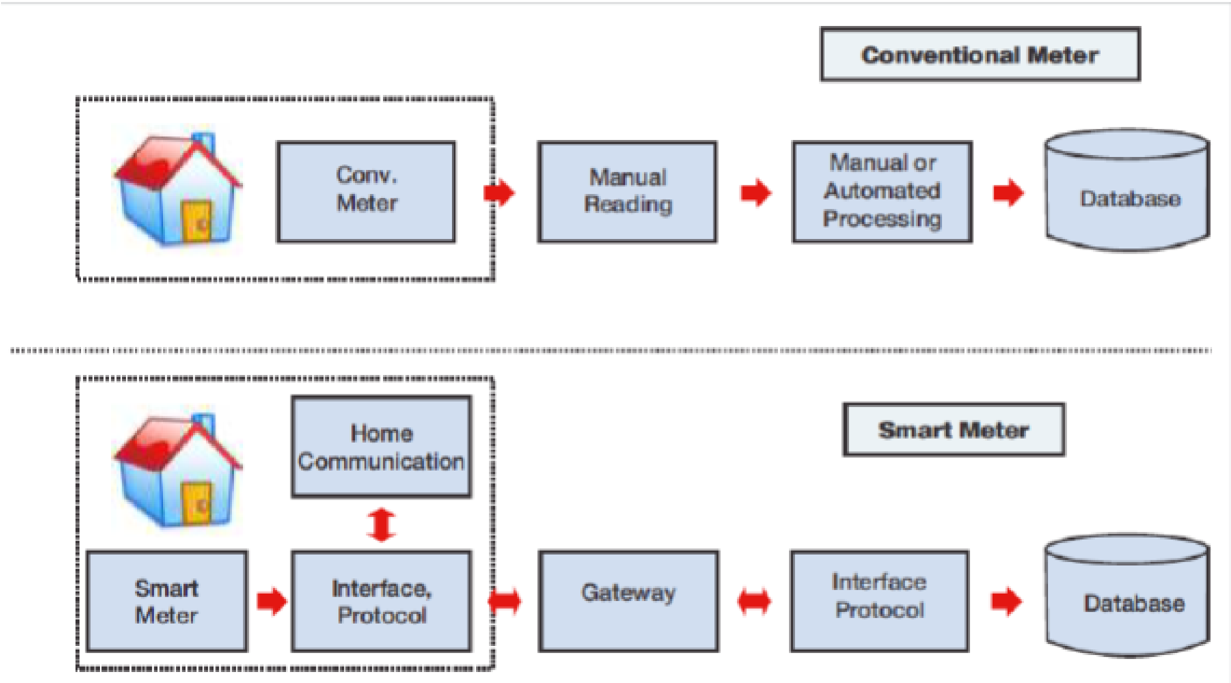


Figure 3 Difference between Conventional and Smart meter

1.4 Smart Meter's Capabilities

Smart metering generally involves the installation of an intelligent meter at residential customers and the regular reading, processing and feedback of consumption data to the customer. A "smart" meter has the following capabilities:

- real-time or near-time registration of electricity use and possibly electricity generated locally (e.g., in case of photovoltaic cells);
- offering the possibility to read the meter both locally and remotely (on demand);
- remote limitation of the throughput through the meter (in the extreme case disconnection of the electricity supply to the customer)
- interconnection to premise-based networks and devices (e.g., distributed generation)
- the ability to read other, on-premise or nearby commodity meters (e.g., gas, water).
- Usually, a smart meter is considered for registry of electricity and gas use, but also water consumption registration is a possibility.

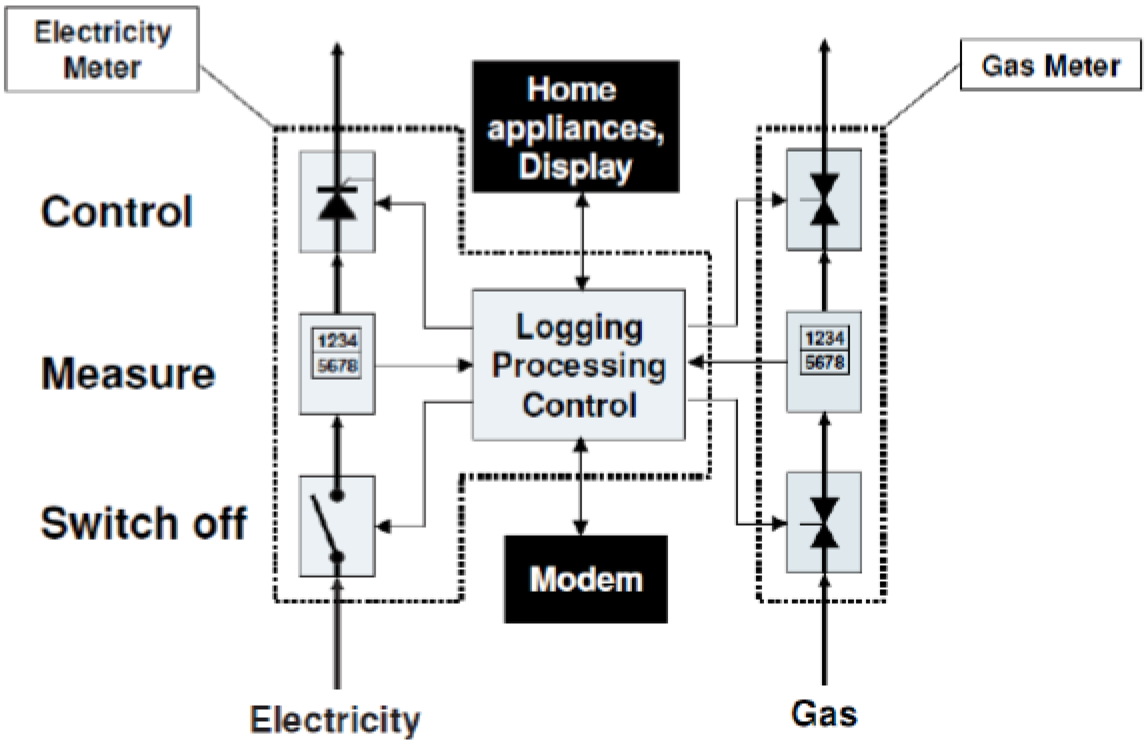


Figure 4 Schematic overview of a typical smart meter configuration

The 'intelligence' of the meter is incorporated in the electricity meter. It has three basic functions: measure the electricity used (or generated), remotely switch the customer off and remotely control the maximum electricity consumption. The electricity meter communicates by means of a modem. An important characteristic is the communication infrastructure used by the smart meter for this communication. Amongst the possibilities are Power Line Carrier (PLC, using the existing electricity grid); a wireless modem (GSM or GPRS) or an existing permanent internet connection (ADSL). An interface connects the smart meter to home appliances or a home display. Appliances can be controlled directly and the display can be used to show (historic) energy data and energy cost. In this example a gas meter is coupled to the electricity meters and borrows the "intelligence" and communication facilities of the electricity meter.

Technologically, there are no obstacles for the introduction of smart metering. The Italian case (roll out of approximately 30 million smart meters at residential customers) and numerous demonstration projects in other countries show that the technology (smart meter, infrastructure, data processing) is mature and can be implemented on a large scale. A smart meter is a logical successor of the mechanical electricity meter, just as the pick-up, the dial phone and the typewriter are replaced with digital, more intelligent alternatives.

Smart Metering is often referred to as automated meter reading (AMR), or in the case of real time, two-way communications, as advanced metering infrastructure (AMI).

1.5 Trends for smart metering applications

Smart metering applications are needed to support the introduction of smart metering capability across three dimensions:

• The implementation of new technologies to enable remote collection and processing of significantly larger volumes of meter data.

• Modifications to existing systems to support remote meter functionality, management of new asset classes, new billing options, and interaction with operational systems such as outage management.

• The implementation of new "valueadd" capabilities such as analytics and additional integration to optimize the benefits and returns from smart metering investments.

Application	Current position	Future trend
The head end	• Relatively immature technology that has historically been structured around proprietary network solutions	• Move to nonproprietary networks will drive head-end solutions to increasingly support standardized protocols across multiple communications technologies
Meter data management systems (MDMS)	• Relatively mature core solution • Packages provide strong performance on most functions, though some utility-specific analysis requirements can cause problems if not managed carefully	• Packaged solutions will dominate rollouts • Extension of MDMS to support complex analytics solutions to increase benefits proposition • MDMS will scale to more than 20 million to 30 million meters
Application integration	• Driving increased value from integration of meter data with outage management systems, asset analytics and customer systems	• Extension of integration to third-party systems, such as to transmission operators for load forecasting, and to potential providers of in-home solutions, such as energy management companies
Analytics	• Largely an underutilized area of value for existing deployments, though becoming recognized as a key next step for many utilities with AMI • Application of existing business intelligence approaches to meter data is starting to demonstrate the scale of benefits available	• Increasing demand for real-time analytics will drive the use of cloud-scale computing and integration with nonstandard, unstructured data sources
Portals	• Smart meter data generally being incorporated into existing utility portals	• Increasing requirements to access real-time data, support for smart devices and integration with social sites

Table 1 Trends in smart metering applications.

Chapter 2

2. Global Market trend in Smart Metering

The use of such smart meters has been growing quickly in recent years. In fact, certain market observers estimate the global market for smart meters will rise from $4 billion in 2011 to approximately $20 billion in 2018. Government policy mandates and fiscal incentives have been the primary drivers of demand for smart electricity meters in a multitude of markets, and tend to attract manufacturers that are seeking to expand their global presence.

Smart metering deployment represents a common first step into smart grid solutions at scale for many utilities. The 10 largest national deployments worldwide are expected to add 500 million new smart meters by 2020, approximately tripling the 2012 global installed base, and the locus of growth shifting from North America to Europe, then Latin America and Asia. Despite the ongoing rollouts, many utilities are still unclear about the optimal route to extracting value from these large investments. Whether utilities are at the stage of planning, preparation or actual deployment, the blanket term "smart" masks a more complex reality. Smart metering means different things to different utilities, given the variety of prevailing industry structures, legal frameworks, regulatory mandates, availability of technology, network infrastructure stability and the operational environments. There is a wide array of possible approaches to deploying smart technologies and benefit areas on which to focus most aggressively.

Smart meters were introduced in the United States and grew in market share compared with analog meters during the 1980s and 1990s, while such developments as the Internet and better energy storage helped to improve the technology. There are two main types of smart meters: automatic meter reading (AMR) and advanced metering infrastructure (AMI). AMR meters use one-way communication and primarily act as digital "meter readers," while AMI meters can use two-way communication to both transmit usage information and perform observation and maintenance tasks. Smart meter manufacturers often produce both AMI and AMR meters and sell them to multiple types of utility customers, including buyers of gas and water, as well as electricity; many firms also make modular meters that are assembled according to final use. Many markets, including the United States, are primarily installing AMI smart meters. The demand for smart meters that specifically monitor electricity has experienced strong growth over the past five years as regions and utilities adopt the technology.

Governments typically have been the principal drivers of growth in the global market for smart meters through mandated use and incentives. In fact, according to one industry assessment of global smart grid projects, government investment propelled nearly all of the initiatives identified across Europe and in seven individual countries. Once installed, smart meter technology usually results in savings for both utilities and consumers, but most utilities are reluctant to invest in the new technology without a government mandate or incentive to do so. Utilities tend to have limited budgets for capital expenditures, and smart meters are among many competing demands for those resources. Further, utilities may not realize the benefits from smart meter installation for several years, making the investment less attractive in the absence of government incentives.

Several countries have enacted legislation mandating adoption of smart meters as part of broader clean energy initiatives. In 2008, for example, the United Kingdom mandated that 53 million smart electric and gas meters be deployed in homes and businesses by 2019, though that deadline was recently extended to 2020 in order to accommodate technological challenges. The program is valued at £12.1 billion ($19.5 billion) and has attracted the interest of a wide range of multinational smart meter manufacturers. Further, the European Union (EU) has enacted a mandate that requires utilities in all of its member states to provide smart meters to 80 percent of their electricity consumers by 2020. This will create substantial new markets for both domestic and foreign suppliers. It is estimated that the market for smart meters in Central and Eastern Europe alone will reach $10.3 billion by 2023. In China, the government released its smart grid plan (Special Planning of 12th Five-Year Plan (2011–15) on Smart Grid Major Science and Technology Industrialization Projects) in May 2012, calling for massive investment in smart grid technology. As part of the plan, the State Grid Corporation of China announced that it would deploy 300 million smart meters by 2015 and up to 380 million meters by 2020.

Direct government funding of smart meter adoption has been more common than legislative mandates. In the United States, for example, the 2009 American Recovery and Reinvestment Act (ARRA) funds specifically earmarked for smart grid development played a significant role in the growth of the domestic market. France has announced a program that would channel $15 billion into digital infrastructure with an allocation for smart meters. The plan calls for the installation of 3 million smart meters by 2016 through the national utility, Électricité de France (EDF), scaling up to 35 million meters by 2020. Up to 80 percent of each meter will be manufactured in France, and smart meters will eventually be exported by EDF, the world's largest producer of electricity.

2.1 U.S. Smart Meter Market

U.S. demand for smart electricity meters comes from a broad range of commercial and personal home users. According to the Federal Energy Regulatory Commission (FERC), as of December 2013, U.S. smart electricity meter penetration was estimated at 22.9 percent, or 38.1 million installed smart meters deployed throughout the United States, up from 8.7 percent in 2010. More recent data suggest that the number of advanced meters in the United States may have reached 45.8 million (or 30.2 percent penetration) in 2014.

State-level policies and incentives and local utilities' willingness to adopt the new technology are also important drivers of U.S. smart meter penetration rates. Both California and Texas have implemented smart grid policies, in part due to rising energy consumption. Many states with high penetration rates for smart electricity meters in 2012 experienced a large increase in total smart meter adoption between 2008 and 2012. The timing of this jump varies by state and may be attributed in part to electric utilities engaging in large smart meter rollouts, some of which came in response to the ARRA funding. California and the District of Columbia topped the list of smart meter penetration rates, at 87.1 percent and 70.5 percent respectively, in 2013. At the opposite end of the spectrum, six states still had advanced smart meter penetration rates of under 1 percent as of December 2012: New York, New Jersey, Hawaii, Rhode Island, Vermont, and West Virginia. Overall, 28 U.S. states are estimated to have smart meter penetration rates of less than 25 percent by 2014.

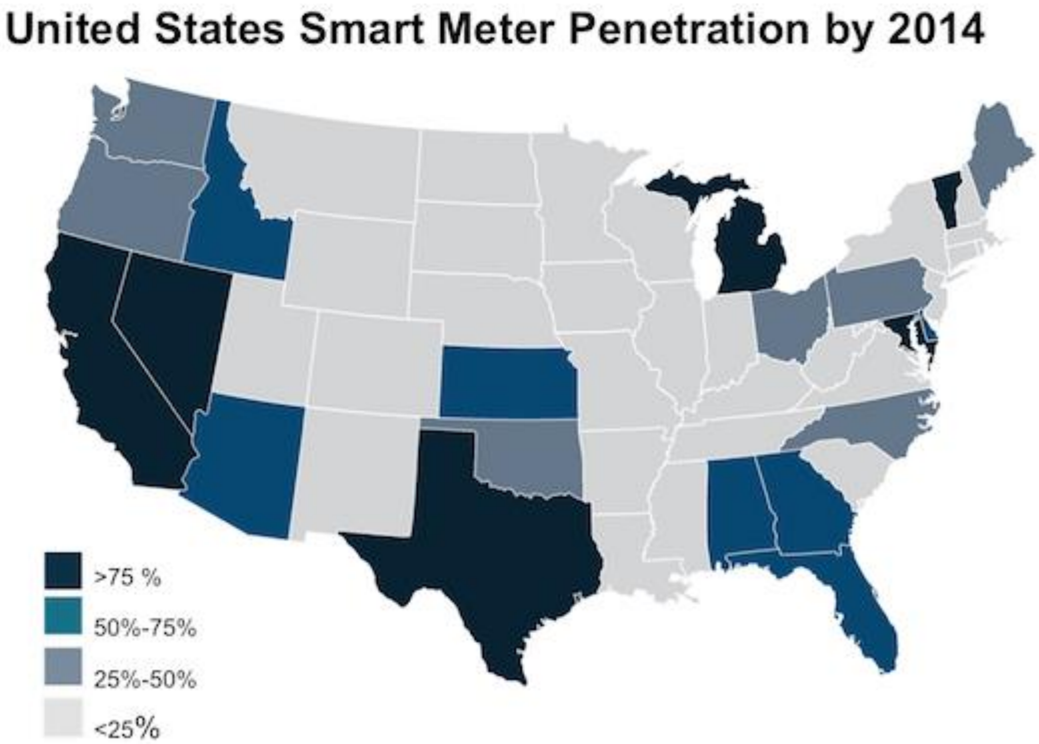


Figure 5: Expected Smart Meter Penetration by U.S. State

Source: GTM Research, cited in Lacey, "The U.S. Smart Meter Market," March 6, 2014

Currently, most demand for smart meters in the United States is for residential meters, since many U.S. commercial customers have long had smart meters to monitor facility electricity usage more accurately. The bulk of residential smart meters are procured and installed en masse by utilities.

Utilities have a number of strong incentives to implement smart meter infrastructure, including improved data reporting. AMI meters transmit data more frequently than can be done with traditional AMR meters, which allows utility companies to more accurately forecast demand and set rates based on usage. Other, less direct benefits exist as well. Smart metering saves money for electricity providers by allowing them to provide a variety of services remotely, including meter reading, disconnecting and connecting consumers, and identifying issues at the point of service. Utilities are also able to better monitor consumers, including outage and failure monitoring. Along with alerting utilities to coverage gaps, smart meters can actually transmit "last gasp" messages back to the utility before failure so that utilities can respond rapidly to outages. Customer service can become more efficient, because issues can be automatically flagged by the system rather than requiring a customer report.

Smart meters can also benefit electricity users, as the meters give them ready access to their electricity usage data. With frequent updates, consumers can easily use these data to control usage or costs. Of the 38 million installed advanced electricity meters in the United States as of 2014, 17.5 million smart meter consumers were reported to have online access to their personal electricity usage data through their utility provider. This represents a more than 300 percent increase in smart meter users with Internet access to their personal electricity usage data since 2010.

Another factor that may affect advanced meter adoption is domestic housing starts, which increased in 2013. With smart meters becoming more common, new homes are more likely to have smart meters installed by utilities, increasing both smart electricity meter penetration rates and the absolute number of installed smart meters.

Due to concerns about data privacy and radiation from radio frequency (RF) emissions, some U.S. utilities installing smart meter infrastructure have allowed opt-out programs for customers who prefer not to have smart meters installed at their residence. To allay these concerns, many utilities include a section on their websites explaining why the meters they use are secure. Both utility-sponsored and state government studies into the negative effects of radiation from smart meters have concluded that the level of RF emissions from correctly installed smart meters, even at close range, falls well below Federal Communications Commission (FCC) limits.

There are roughly 40 U.S. manufacturers of smart meters, though the market is dominated by a few large producers and includes smart meters for electricity, gas, and water. Smart meters for electricity make up almost three quarters of U.S. production, followed by smart meters for gas and then water. According to an industry research analysis, three manufacturing companies in the United States account for more than 70 percent of all domestic revenue in the smart meter market, led by Itron with almost one-half the market. In 2012, U.S. employment for production of all types of smart meters was at just over 2,000 individuals.

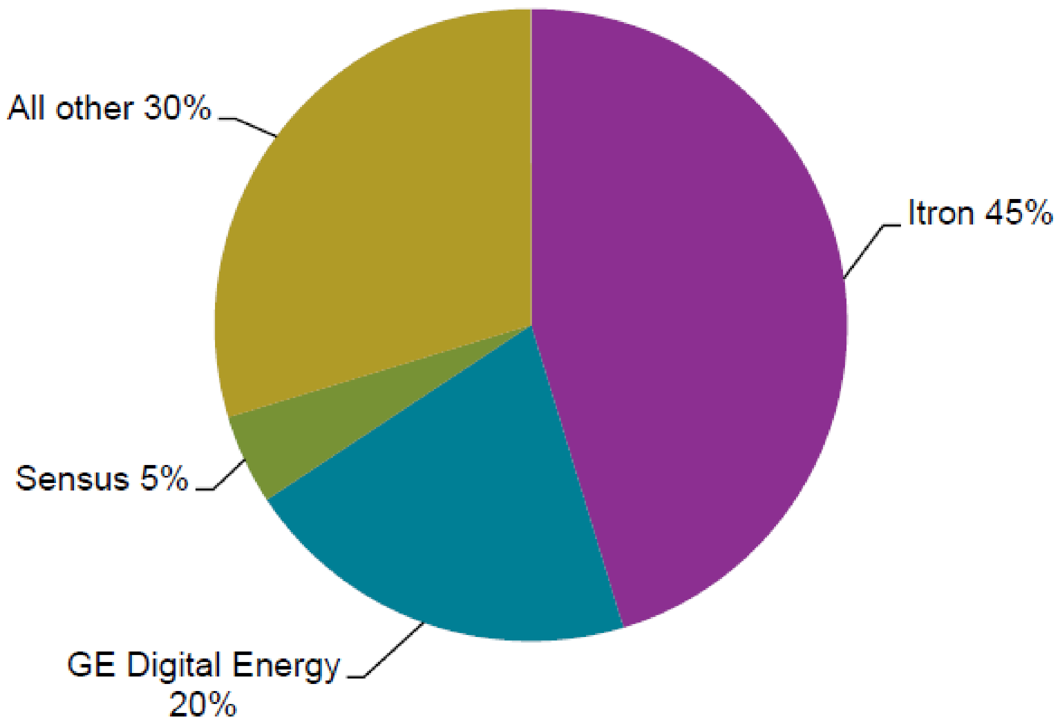


Figure 6 U.S. smart meter market share, 2014

Source: Samadi, *Smart Meter Manufacturing in the US*, December 2014

Smart metering deployments in the United States and Canada (Conclusive)

The deployment of smart meters in the United States and Canada is expected to steadily increase by 2020, representing a penetration rate of about 80 percent. During that time frame, the United States is forecast to add close to 90 million meters to the current population of 43 million, while Canada is estimated to grow its installed smart meter base from 6 million to between 15 million and 20 million. The nature of the regulatory structures in the United States and Canada means that some states and provinces will delay smart meter deployment due to cost/ benefit concerns. However, many of the largest population centers are covered by mandated rollouts or by approved agreements with the local regulators.

2.2. European Union

Despite the EU's relatively low starting point, policy at the EU and national levels is pushing smart meter initiatives ahead quickly so as to meet the EU's 2020 energy efficiency targets. The Energy Services Directive identified smart meters as one of the main ways to achieve an improvement in energy efficiency. According to the Electricity Directive, at least 80 percent of consumers have to be equipped with smart meters by 2020 subject to positive economic assessment of the long-term costs and benefits, to be carried out by each member state.

The EU's smart-meter rollout is getting underway. By mid-2011, an estimated 42.3 million smart meters had been installed in the EU, mainly as the result of large rollouts in Italy, Sweden, Finland, and Denmark, this total is estimated to have risen to 61 million by the end of 2013. Industry observers expect the rollout to gather considerable steam in coming years, with compound annual growth in installed smart meters of nearly 20 percent over the next six years. By mid-2012, the EU Commission had catalogued about 90 smart metering pilot projects and national roll-outs, as well as 281 other smart grid projects.

However, meeting the EU's smart-metering goals will take some time. By the end of 2013, smart meter penetration for all metered electricity customers was only 22 percent. Navigant Research estimates that total smart meter shipments in Europe in the quarter ending June 30, 2013, represented just 2 percent of the 25.5 million meters shipped globally. It is estimated by industry sources that the installed base of smart meters in Europe will be just fewer than 230 million by 2020, that the penetration rate for smart meters will approach but perhaps not reach the mandated 80 percent by 2022. The value of smart meter sales in Europe is forecast to grow from around $318 million in 2010 to as much as $1.93 billion in 2017. By 2016, advanced metering infrastructure (AMI) is expected to account for the majority of the EU's total smart grid market with 44 percent, and distributed automation (mainly in the form of automation of secondary substations) is expected to account for 33 percent.

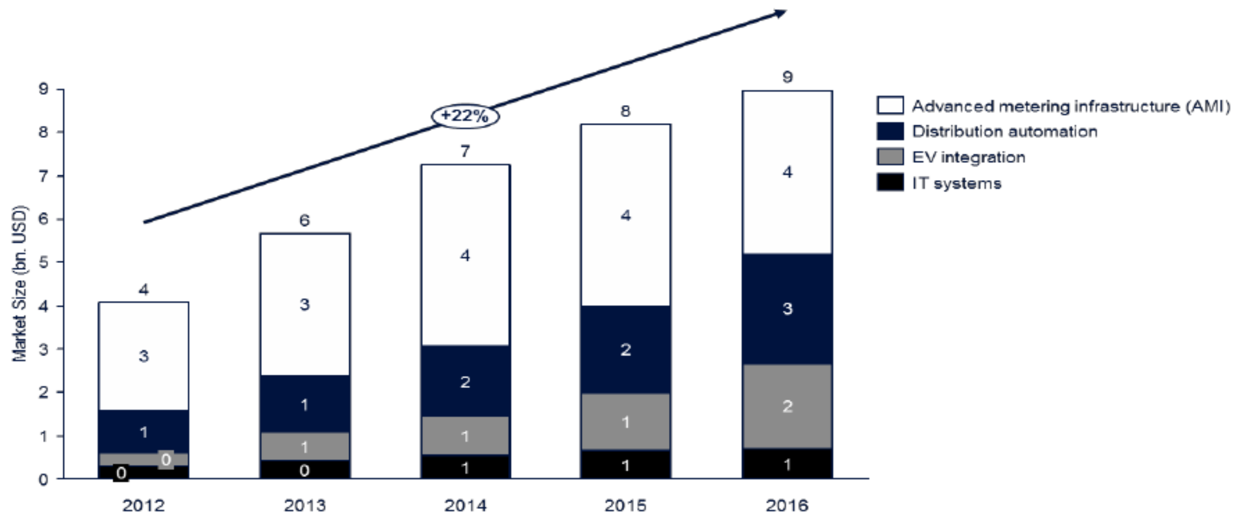


Figure 7 Growth in European Smart Grid Spending: Average annual growth forecast for 2012–16

Source*: The Global Cleantech Report 2013*

France, in particular, are expected to drive growth in smart meter shipments in Europe through 2020, while Sweden and Italy are already mature markets with 100 percent rollouts completed by 2010. In addition, some Eastern European nations are pursuing smart metering as a means of energy theft reduction. EU member states that have taken the decision to roll out electricity smart meters include the UK, Ireland, Sweden, Finland, Norway, Denmark, the Netherlands, France, Spain, Italy, Austria, Slovenia and Estonia. Following a cost-benefit analysis (CBA) with negative results, Belgium, Lithuania and the Czech Republic decided not to carry out a smart meter rollout. Germany's cost benefit analysis was also negative, and a full-scale rollout is therefore unlikely.

2.2.1 Smart Meter Deployments in UK

The UK government has mandated a full rollout of smart meters and other smart grid improvements to deregulated utilities. Its strategy was to have an initial preparation phase, including consultation with industry, consumer groups, and other stakeholders, in 2011–2013. This was to be followed by an implementation phase starting in 2014 and running through 2019 to install 53 million smart meters in 30 million homes and businesses. The total cost of the project was estimated to be about £12 billion.

In December 2012, the UK government published its decisions on rules for consumer engagement, privacy, and security, establishing the following requirements:

(1) Consumers will be able to choose the frequency with which their energy suppliers can access their consumption data;

(2) Energy suppliers will not be able to use energy consumption data for marketing purposes without explicit consent from consumers; and

(3) Suppliers must remind their customers of their previous privacy choices and give them opportunities to change their minds.

In May 2013, the government announced that the rollout phase would be delayed by one year to 2015–20, in order to allow industry suppliers more time to prepare. In particular, the communications infrastructure needs further trial and testing, which is a complex exercise. Shipments of smart meters have not been very significant to date, but manufacturers are confident that the expected large deployment will materialize in the next few years in line with the government timetable.

The UK smart metering rollout: A unique deployment that might offer valuable lessons (Conclusive)

The United Kingdom is embarking on a substantial deployment of smart meters, with more than 50 million electricity and gas meters due to be deployed, costing close to £12 billion. Although the UK smart metering rollout differs markedly from every other global deployment, it could end up providing a wealth of insights for all deployment programs. Its most fundamental characteristic is that it is retailer-led within a competitive retail market. As a result, the deployment approach taken by each utility will need to take into account both the optimization of installation and the potential to improve its retail position, particularly with its most valuable consumers. Beyond the potential efficiencies in meter operations, there is value in attracting and retaining the best consumers. Given this background, utilities around the world may learn some valuable lessons from the way the retail product set in the United Kingdom evolves—helping to answer questions such as: What do consumers want, and will beyond-the-meter services be part of the solution? For example, one utility has already raised the possibility of offering free electricity on Saturdays in return for customers switching more of their usage away from the working weekdays.

In the United Kingdom, meters generally sit inside people's homes, meaning most installations require appointments and a well-trained, consumer-aware workforce. While the need to enter homes increases the brand risks from poor delivery, it also opens up the potential for training consumers on solutions offered by the meter and in-home devices. So varying approaches by the utilities involved could easily lead to different outcomes in energy conservation and in the uptake of additional products and services.

Given the relatively high level of UK consumer switching, interoperability will be key. Considerable effort will be invested in verifying that expensive assets need not be replaced when consumers change retailers or sign up for new products. Also, the approaches the United Kingdom adopts for managing consumer data will provide useful comparisons for many utilities in other markets.

Another distinctive characteristic of the United Kingdom is that prepayment is likely to be a significant component of the offered solutions. Already, about 15 percent of UK electricity meters use prepayment —a higher proportion than in most other developed countries, and the number of consumers with prepayment meters has been growing in recent years. The potential to provide prepay solutions at a lower cost than using traditional prepayment meters could result in growth of the prepay approach and its extension into new consumer segments, mirroring the use of prepay in mobile phone services.

While smart meters have significant potential to improve the service levels provided to repayment consumers, they also open opportunities for new tariffs and demand-response products to help manage grid constraints and renewable integration.

Unlike with many rollouts, the UK deployment will enable consumers to retain ownership of their energy data. Utilities would only have the rights to the basic data required to deliver against their statutory commitments. This separation limits utilities to providing services such as basic billing and last-gasp alerts signaling an outage, unless the consumer explicitly agrees. This situation opens up the prospect of a type of market developing for consumer data—in turn, raising the question of how many utilities would have to pay to gain additional access to that data. It would also be instructive to see if the UK model of consumer data ownership helps to improve consumer acceptance of smart meters, and whether this approach is adopted by other countries.

2.2.2 Smart Meter Deployments in *France*

France is just beginning its large nationwide rollout. Per a July 2013 decision, the government plans to initiate a pilot smart meter program for a widespread deployment of 35 million new smart meters from 2014 to 2020. The government is expected to begin procurement for its national rollout in 2013.

2.2.3 Smart Meter Deployments in *Spain*

The Spanish smart meter rollout is underway and is expected to gather pace in coming years, with the upgrading of around 29 million meters. In mid-2012, smart meter shipments in Spain were running at an annual rate of more than 1 million units. A year later, it was reported that Spain continues to deploy smart meters in sizable volumes. For example, Endesa completed a program installing 3.5 million smart meters by the end-April 2013, equivalent to about 30 percent of the existing residential meters in Spain.

2.2.3 Smart Meter Deployments in *Germany*

Of the five largest countries in the EU, representing around 60 percent of the EU's potential smart meter market, only Germany has yet to make an explicit commitment to a nationwide rollout, which is expected to cost as much as €33 billion. Although smart meters have been required after major renovations and on new buildings since 2010, the rollout to existing homes has remained in the pilot phase, awaiting the outcome of the required cost-benefit analysis. (By mid-2012, about 500,000 meters had been deployed as part of large-scale pilot projects.) In August 2013, the Federal Ministry of Economics issued a report concluding that a full rollout of smart meters would not deliver economic benefits for German consumers. As a result of the report, Germany has delayed its full rollout until at least 2020. Concerns about privacy and retention of personal data and patterns of energy use figured strongly in the survey responses from some energy users, indicating the depth of public concern about the potential for breaches of privacy.

Smart metering deployments in Europe (Conclusive)

Europe will experience a significant increase in smart meter deployments to 2020, driven by government mandates and market factors. It is estimated that a total of around 200 million new smart electricity meters will be deployed across Europe, bringing the region's total smart meter population to approximately 240 million. Most European countries have adopted mandates for deployment, with a key part of the overall expected benefits being the potential to help meet their obligations under the European Union's "20-20-20" climate change targets. This set of binding legislation aims to ensure the European Union meets its ambitious climate and energy goals for 2020 through reducing greenhouse gas emissions by 20 percent compared to 1990 levels, increasing the share of renewable by 20 percent and delivering a 20 percent reduction in consumption.20 The only large European nation to not have mandated deployment of smart meters is Germany, but major rollouts are still expected based on the separate market assessments made by individual German utilities.

2.3 Asia Smart Meter Market

According to one recent estimate, the combined smart grid technology market for China, Japan, and South Korea (including smart meters but also including transmission and distribution automation equipment and services) totaled nearly $8.5 billion in 2012 and will grow to $19 billion by 2016. China represents about 70 percent of the total, while Japan and Korea represent 20 percent and 10 percent, respectively.

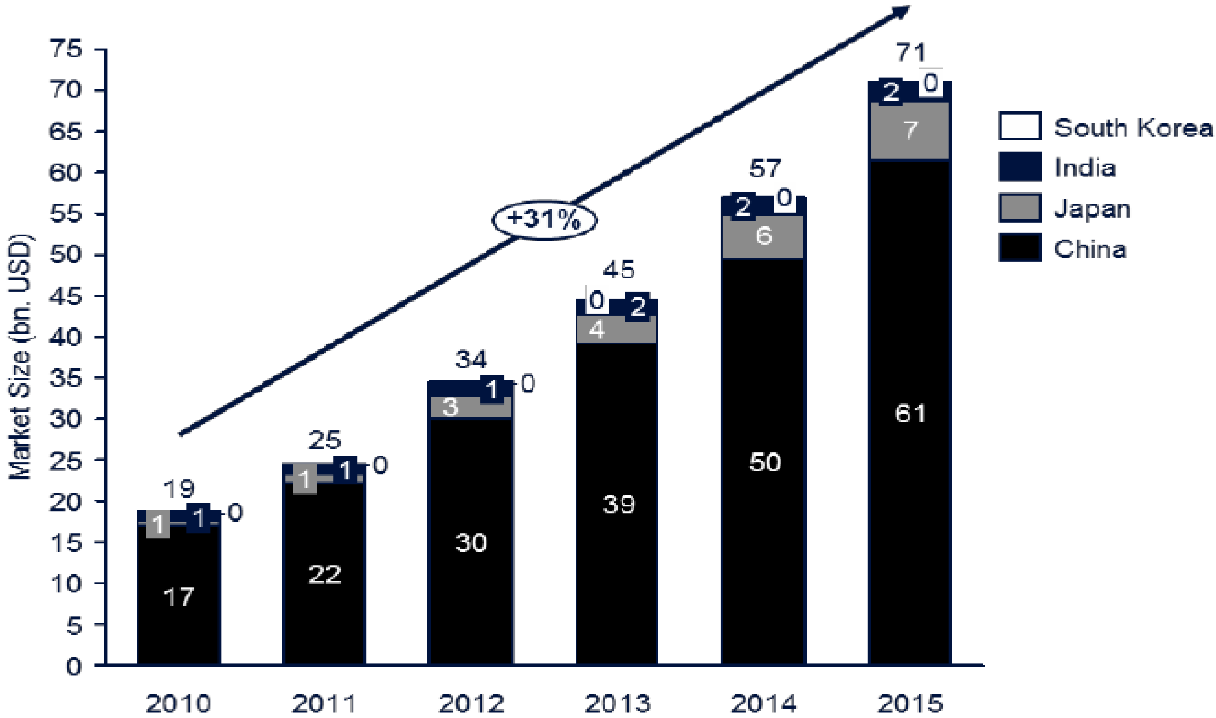


Figure 8 Asia Smart Grid Market Size *Source : The Global Cleantech Report 2012*

2.3.1 China

China has become the world's largest market for smart electricity meters as a result of several initiatives by the Chinese national government. The installed base of smart meters in China is expected to grow from 139 million units in 2012 to 377 million units by 2020, reaching 74 percent market penetration. The Smart Grid Corporation of China (SGCC) is China's sole state-owned electric utility company and the largest utility company in the world, affecting 1 billion people. In the past five years, the SGCC has sought ways to upgrade the power industry (including energy-equipment manufacturing), reduce the deployment of new coal-fired power plants, ensure reliable power supply, and maintain national power security.

China hopes to phase out traditional electric meters by 2016.98 Smart meter bids for future projects across China added up to 76 million units in 2012, with single-phase meters that serve homes and small to medium-sized businesses accounting for 92 percent of that total. Reportedly, China's customer base demands smart meters at price points of less than $50 per unit for residences, less than half of the typical price in North American and European smart meter markets.

China's smart meter industry is served by both domestic and foreign companies, although the market remains highly fragmented. For example, three of China's top smart meter producers, Wasion Group, Linyang Electronics, and Ningbo Sanxing, each held less than 6 percent market share in single-phase meters in 2012.101 Many Chinese smart meter producers are forming partnerships with foreign companies, allowing the foreign firms to penetrate the Chinese market and giving the Chinese firms access to foreign technology.102 Foreign companies selling smart meters in China through joint ventures include General Electric, Siemens, Schneider Electric, Alstom, Toshiba, and Mitsubishi.

Smart electric meters in China are mainly sold to utilities through centralized bidding. Both foreign and domestic firms have been successful in winning bids. In January 2011, Landis+Gyr were selected by SGCC to supply over 10,000 smart meters for deployment in six provinces. Chinese-based Holley Metering won a SGCC bid worth $53.73 million in 2010. In March 2012, Echelon Corporation, a California-based company, and Holley Metering formed a joint venture company, Zhejiang Echelon-Holley Technology Co., Ltd. (Echelon-Holley), to focus on the development and sales of advanced smart metering products for China. In October 2012, Echelon-Holley received orders from SGCC for 30,000 smart meters for a pilot installation project in the Inner Mongolia autonomous region, and 1,000 smart meters for another pilot project in Shanxi province.

2.3.2 Japan

In 2011, Japan's smart grid technology market totaled approximately $625 million, but this is expected to increase sharply over the next five years to reach $7.4 billion in 2016. Sales of

AMI meters, the largest segment in this market at around 40 percent of the total, are projected to grow from about $250 million in 2011 to $2.5 billion by 2016.

Before the Fukushima earthquake disaster, Japan had adopted a cautious approach to smart grid deployment. Afterwards, however, when continued nuclear-fueled electricity generation became a concern, the government's approach became more proactive, and it established the Energy-Environment Council to develop the policy response to a proposed switch away from nuclear power. The council issued a report in July 2011 which emphasized the need for efficiency and conservation measures as well as supply-side measures, including introducing smart meters and a revised electricity tariff system. The Japanese government set a target for about 80 percent of the nationwide electricity consumption to be monitored using smart meters, to be phased in over the next five years. Also, the government is supporting four Smart cities projects through its development fund in order to establish Japan as a leader in smart grid design.

The two power utility giants, Kansai and Tokyo Electric Power Company (TEPCO), have essentially redesigned the market landscape for electricity distribution in Japan to respond to government targets. Kansai Electric Power was a first mover; it has been installing smart meters since 2008. During the year after the Fukushima crisis, the government ordered the now mostly state-owned TEPCO to invite bids from both domestic and foreign firms for approximately 17 million smart meters to be installed by 2019. In early 2013, TEPCO began selecting vendors for AMI-related services, and announced that Toshiba would play the role of system integrator and supply the communication system for its residential smart meter rollout. In July 2013, TEPCO announced that it was accelerating its rollout, expanding the program from 17 million new smart meters to 27 million meters (essentially all of its household customers' meters). Installations were to begin in the first half of 2014 and are to be completed by March 2021. Smart metering services for customers—such as providing customers with detailed data on energy use patterns—will be introduced in July 2015. The utility announced in November 2013 which meter manufacturers will supply the first tranche of the program (1.14 million meters): Mitsubishi Electric Corp, GE Fuji Meter Corp., and Toshiba Toko Meter Systems. TEPCO's acceleration of its smart-meter rollout is probably at least partially motivated by the cost cutting and corporate restructuring that followed Fukushima.

With such a large rollout underway, meter manufacturers are working hard to strengthen their ties with the utilities, as they submit bids to supply to the major utility companies. Toshiba, which bought meter giant Landis+Gyr in 2011, appears well positioned to expand on its success in winning the TEPCO AMI contract; the two companies have recently established a joint venture to supply engineering support services to transmission and distribution companies around the world. Also, Toshiba is already working with TEPCO on the Yokohama City smart city project. Fuji Electric and General Electric have also established a joint venture to provide smart meters for the Japanese market, while Hitachi, Panasonic, and Osaki Electric have joined to offer meters and other smart grid products and services. Along with GE, other foreign meter makers, including Enel SpA, Echelon, Elster, and Itron, are also likely to compete in the Japanese market and have established partnership arrangements to this end.

2.3.3 Korea

Korea's push for smart meters is part of the Smart Grid Initiative announced by the Korean central government in 2009. Spearheaded by a demonstration project on Jeju Island, the initiative is intended to help reduce overall energy consumption by 3 percent and cut electricity consumption by 10 percent by 2030. The Korea Smart Grid Institute (KSGI), the government body responsible for Korea's smart grid projects, states that the Korean government plans to invest a total of $1.1 billion dollars in smart meters by 2030 (from 2012). According to KSGI, smart meters can help to redress the limited functionality of Korea's current electricity utility communication systems, particularly the labor-intensive process and inaccurate readings of electric meters, along with Korea's escalating power losses due to inefficiencies.

Currently, the Korea Electric Power Company (KEPCO) is focused on installing smart meters for residential customers, which make up about 14 percent of national energy consumption. KEPCO plans to roll out smart meters to about half its households (about 10 million units) by 2016, a 14-fold increase from the 2011 figure. Moreover, Korea's primary government body responsible for energy policy, the Ministry of Knowledge, plans to replace all household analog meters with smart meters by 2020. If Korea meets its 2016 target to install the meters at half its households, reportedly it will be second in Asia only to China in terms of the number of installed smart meters.

Korea's market is supplied mostly by domestic smart meter producers, although these companies sometimes partner with foreign firms to produce meters.

Smart metering deployment in Asia and Australia

The Asia Pacific region is set to dominate the global deployment of smart metering by 2020 (see Figure 14). China is forecast to lead the way, with an installed smart meter population that could potentially approach 400 million by that date. In contrast, it is estimated that India will deploy fewer than 18 million smart meters to its population of more than 1.2 billion people. However, the high potential in India for the deployment of smart meters to support prepayment solutions could result in strong market-led growth in installations.

Elsewhere in Asia, Japan is expected deploy almost 60 million smart electricity meters by 2020, largely under a market driven model. Meanwhile, South Korea is looking to position itself at the forefront of smart grid deployment globally through the government's "Green Growth" policy. As part of its broader smart grid strategy, the South Korean state utility, KEPCO, is looking to deploy between 500,000 and 1.5 million smart meters per year in homes over the next 10 years.

In Australia, only the State of Victoria has made significant deployments, due to a state-level andate. In other Australian states, concerns about the business case and adverse media coverage have delayed significant deployments. This is set to change, however, based on the recently published "Power of Choice" paper by the Australian Energy Market Commission, the national market rule maker, which outlines the framework for a national retailer-led deployment. Further, the deployments in Victoria are starting to extend their solutions to realize value for customers and the utilities involved.

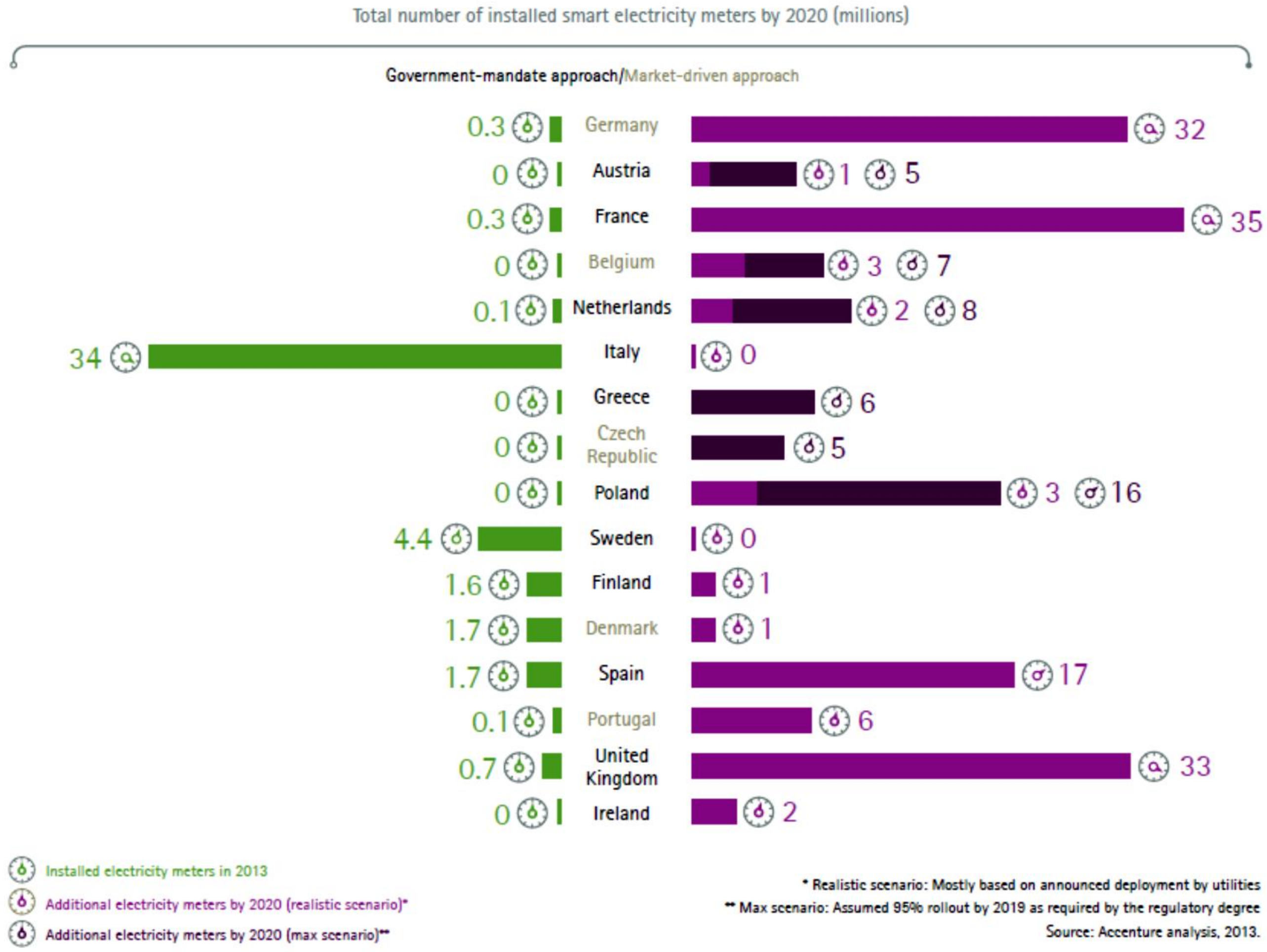


Table 2 Estimated total number of installed smart electricity meters deployed in Europe, by country, by 2020 (millions), *Source: Accenture Analysis, 2013*.

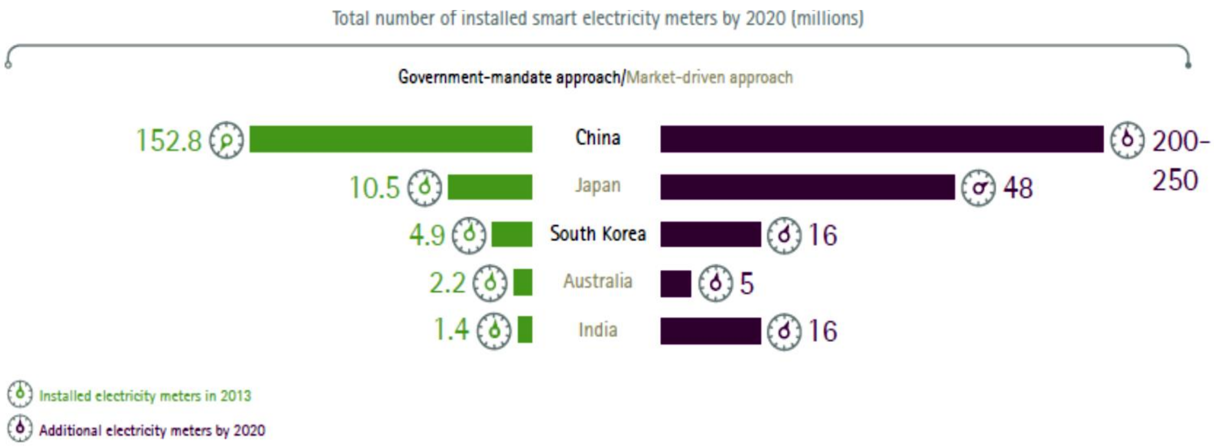


Table 3 . Estimated total number of installed smart electricity meters deployed in Asia Pacific, by country, by 2020 (millions). *Source: Accenture Analysis, 2013*.

Chapter 3

3. Smart Meters for India

3.1 Need of smart metering in India

1) Focused towards Power Shortages

Indian power sector has long battled with the problem of Demand Supply gap. The rising demand cannot easily be met with the current pace of capacity addition. Considering the economies and environmental concerns, industry experts and the government have realized that capacity addition without energy efficiency cannot fill the gap. So utilities are now focusing on demand side management. Demand Response is being adopted as a tool of demand side management, and smart meters support this initiative. With deployment of smart meters the utilities can more efficiently adopt and utilize Time of Use tariff structure. The consumers switching there usage time from peak times to off peak or normal times would help the utility and the whole system overcome the problem of shortage. It is only with real time display of vital information at consumer premises can the consumer move towards energy efficiency. Smart meters employ two-way communication and thus help the consumers to connect with utility and make more informed decisions of switching usage pattern and moving to more energy efficient appliances.

2) Prevention of theft and other losses

Smart Grid development at core would help to overcome the distribution sector challenges of high commercial losses and inefficiency. With deployment of smart meters the basic problem of low billing efficiency and theft can be completely be removed. Smart meters record consumer energy usage after every specified interval of time, so any unusual pattern in consumption or pilferage can easily be detected by smart meters thereby aid in eliminating tampering and theft. With earlier meter types it is not possible for the utility to know the mischievous source But with smart meters detection is instantaneous and utility can even remotely disconnect the user if found guilty.

3) Prevents overloading of system components

Smart metering system facilitates two way communications between utility and consumers. The system also provides the utility the ability to remotely connect some load off consumer premises in case of overdrawing from the consumer en. Smart meter systems alert the utility in case of any system overloading situation and the utility in alert situation can thus take preventive steps.

4) Planning capacity

Capacity addition in India is not taking place at a pace to meet the rising demand. One of the factors why utilities are not able to arrange for adequate supply is improper forecasting. Smart meters provide detailed information on consumer usage. The utility with help of this information can study and forecast consumer demand with more accuracy in future. The information provides details of peak and off peak demand patterns. The utility can conduct asset management more efficiently.

5) Consumer Satisfaction

Smart meter roll out would bring a number of benefits to consumers in terms of accurate bills, accurate and real time information to enable them to manage energy consumption and potentially receive new services. Smart meter will also hold the capability to alert the utility suppliers and networks when electricity supply is lost, thus delivering better outage management service to consumers.

3.2 ToU Metering

Smart grid applications allow electricity producers and customers to communicate with one another and make decisions about how and when to produce and consume. This emerging technology will allow customers to shift from an event-based demand response where the utility requests the shedding of load, towards a more 24/7-based demand response where the customer sees incentives for controlling load at all times. One advantage of a smart grid application is time-based pricing. Customers who traditionally pay a fixed rate for kWh and kW/month can set their threshold and adjust their usage to take advantage of fluctuating prices. Another advantage, mainly for large customers with generation, is being able to closely monitor, shift, and balance load in a way that allows the customer to save during times of peak load, not only kWh. Smart grid applications increase the opportunities for demand response by providing real-time data to producers and consumers, but economic and environmental incentives remain the driving force behind this practice.

The Commission could approve an optional time-of-day pricing tariff for residential and small commercial customers who wish to take advantage of such an opportunity. Of course, the tariff would have to cover the additional metering costs. But if the customers are willing to pay these costs, they should be given the opportunity to purchase electricity on a time-of day rate. Under the traditional timeless price structure, customers may be treated unfairly because they consume relatively little electricity during the peak-usage hours and relatively large amounts during low usage periods, like the middle of the night. Some customers may be willing to modify their usage patterns, in order to take advantage of lower rates. If they do so, it would be advantageous to everyone. These customers would benefit from lower electric bills, while other consumers would benefit from their absence during the peak hours, thereby reducing system fuel costs and the need for additional capacity at the peak hours.

3.2.1 Smart Meters & ToU Pricing

Implementation of Time of Day requires adequate metering infrastructure to be in place as it requires recording the demand and energy consumed in different time slots. Under ToD tariff regime, single phase electronic ToD energy meters should have the facility for data storage, provision for setting tariff slabs, a clock and battery and a communication port. In addition it would require an interfacing device (MRI) for downloading the data, and change in billing software for billing the consumer for different time periods of consumption.

Smart meters track the energy use in your home on an hourly basis and send this information automatically to your local distribution company (LDC). By automating the meter-reading function, smart meters support the implementation of time-of-use prices. By time-stamping your consumption data, local distribution companies will be able to determine how much electricity was used during off-peak times and how much was consumed during on-peak periods.

In the future, smart meters could allow the introduction of different time-based incentive programs, or the opportunity for consumers to control their energy use through energy management devices or smart appliances.

So, it can be deduced that to take advantage of benefits possible by Time of Use pricing, deployment of smart meters with such pricing mechanism in place would provide the best of results. Also, unless ToD pricing mechanism is implemented the whole rationale of consumer involvement would not be realized.

3.2.2 Status on ToU metering in India

Across India various electricity regulatory commissions have introduced Time of Use tariff schemes mainly for industrial and commercial consumers. Results after implementation of ToD for consumers across have shown reduction in losses to the utility and a more optimum usage on the consumer end. Implementation of ToD tariff scheme has not yet been done for domestic consumer category. Studies on consumer consumption patterns have shown that in many states domestic users form a major part of consumption and introducing ToD metering for this consumer category would prove beneficial for the utility.

ToD for Domestic Consumers

The authorities should focus on systems and functions before the full roll out begins and this will provide a foundation for later developments to deliver the planned benefits. Keeping this in view it may be observed that implementation of ToD tariff scheme has not yet been spread to domestic consumer category. Studies on consumer consumption patterns have shown that in many states domestic users form a major part of consumption and introducing ToD metering for this consumer category would prove beneficial for the utility. A recent study for Delhi Transco has revealed that in Delhi domestic consumers dominate the electricity consumption profile not only in terms of numbers but also in load profile. Owing to their dominance in consumer profile domestic consumers also contribute to high peak load. In view of the situation it would be worthwhile to examine the introduction of Time of Day tariffs for residential consumers. By implementing such tariff scheme price sensitive consumers would shift to more energy saving appliances (shifting from incandescent bulbs to CFLs), shift usage to off peak or mid peak times. This would give huge benefits to the utility and also reduce the need of peak plants stressing the environment. So, implementation of ToD with smart meters is a win -win situation both for the utility and the consumers.

3.2.3 Need of ToU Pricing

A review of the generation schedule of the generating stations including short term power scheduled in different time slots across the day in a year reveals that the differences in the cost of power are large enough to warrant time differentiated pricing of electricity at retail supply end. Further, the grid frequency linked UI charges also establish the fact that in 96 time blocks of 15 minutes each the UI rates shows a wide intra – day variations. The prices of electricity that reflect differences in cost to the extent possible are more efficient and convey appropriate price signals to the electricity users. Hence ToD tariff needs to be designed to encourage large consumers of electricity to shift their electricity consumption, to the extent possible, to off peak period thereby flattening the system peak, thus avoiding expensive power.

Another important point to note is that domestic consumers pay tariffs that are lower than the average cost of supply. If we consider the voltage wise costs and losses, the gap between the averages cost of supply and average tariff further increases. The above implies that for every unit of electricity sold to domestic consumer, the utility doesn‗t recover proportionately, which affects its financial viability. This also results in increased pressure on subsidizing consumer's viz. commercial and Industrial due to presence of cross subsidy in the tariff structure.

TOU prices take into account when, as well as how much, electricity is used to better reflect real differences in the cost of supplying electricity at different times. TOU prices can also provide an incentive to shift load, that is, move some usage away from peak periods to off-peak and mid-peak periods when the cost is lower. Expensive sources of electricity supply, primarily natural gas ―peak plants‖ are needed to meet these periods of high demand. However, TOU pricing in concert with other conservation measures can reduce the need for future peak plants.

3.2.4 Points to be considered for implementation

A common ToD tariff for all slabs may result in distortions with consumers in lower slab paying higher tariff in comparison to the existing rates and those in higher slabs paying much lower. Thus, the tariffs have to be designed so that there is a separate set of three different rates i.e. peak, off peak and normal for each consumption slab. Thus for the purpose of rationalizing the impact of on consumers of different consumption levels, ToD tariff is designed such that the revenue from each slab does not change.

3.3 Barriers to deployment in India

1) Cost of overhaul Present system cost

Some older equipment must be replaced as it cannot be retrofitted to be compatible with smart meter technologies. This may present a problem for utilities and regulators since keeping equipment beyond its depreciated life minimizes the capital cost to consumers. The early retirement of equipment may become an issue. The utilities would thus need to conduct a thorough cost benefit analysis of the smart metering system keeping in view the cost and life of the installed system. This becomes even more important for Indian utilities which are not in financially competent state.

2) Financing

The business case for a smart metering is good, particularly if it includes societal benefits. But regulators will require extensive proof before authorizing major investments based heavily on societal benefits. Finding sources of project financing would require cumulative effort of utilities and the government. A detailed cost benefit analysis projecting the probable higher financial benefits of smart meter deployment is required to be done to convince the financers.

3) Government Support

The industry may not have the financial capacity to fund new technologies without the aid of government programs to provide incentives for investment. The utility industry is capital-intensive, but has been sustaining exorbitant losses due to thefts and subsidization. Smart meter deployment across the country would be a huge plan changing the dynamics of the system in great manner. So, a project of such nature would require government‘s financial and regulatory support for successful implementation.

4) Development of technology for Indian scenario

Smart meter system is a new technology concept for Indian power sector. Internationally the technology has been employed in various countries but utilities would need to study and adapt the system technology to fit the Indian sector. The utilities in coordination with government representatives need to develop the technology considering the country‘s economic, geographic and demographic characteristics. A deep research and development study needs to be carried out keeping in view the need of interoperability of the system.

5) Trained Manpower

As stated above smart meter technology or for that matter smart grid technology is new concept under proposal in the Indian power sector. Consequently the sector lacks trained manpower with required skill and expertise in the sector. Smart metering system will involve are require a more technology savvy workforce but the present manpower is ageing with not efficient knowledge of computers. Skilled manpower having the knowhow of the Indian scenario is essentially required for successful implementation of the project.

6) Development of Communication Technology

Communications infrastructure is costly, yet is at the heart of the smart grid vision. As we move deeper into a smart grid world, communication will play an ever-larger role in the power sector. Often, utilities will argue that they should build their own communication infrastructure owing to reliability and security concerns. This could result in the duplication of infrastructure, and as stated, the electricity sector may not have the band-width in term of skills to engineer, procure and implement this technology. This suggests that it might be advantageous to encourage close coordination between the telecommunication and power sectors, with the participation of policy makers and regulators.

7) Passing on of cost to customers

Many utilities are proposing to recover these costs via a customer surcharge. This is not reasonable, based on the view of cost causation, and will have disproportionate adverse impacts on low-usage customers.

8) Consumer awareness

Customer response‖ is the phrase used to describe the reaction of customers to the new features and functionality enabled by the smart metering system. If, for example, a company installs advanced metering and two-way communication along with time-of-use rates, the question is ―Will customers use it?‖. If there aren‘t enough customers who use the features, the benefits of a smart metering will not be achieved. Thus, two critical components of smart meter implementations are 1) sufficient marketing analysis and product design to optimize the likelihood that customers will use the new technology, and 2) an education, communication and public relations program aimed at creating an understanding of smart grids, the associated benefits and the potential implementation issues. The program should be aimed at customers but also policy makers, opinion leaders, regulators and financial institutions.

9) Cost Assessment

Costs could ultimately be higher than projected because the standards and protocols needed to design and operate an advanced metering infrastructure are still in a state of flux. Thus, investments made now, before the standards are settled, have a higher risk of obsolescence. Failure to include estimates of the costs for the control equipment customers will install to automate their response to time-differentiated pricing could put smart grid investments at risk. Other risks include 1) no demonstration that the proposed project is more cost-effective than alternative approaches that will achieve the same major energy cost reduction objectives at less cost and 2) exclusion of incremental costs of ―stranded‖ existing meters (i.e., accelerated depreciation).

10) System security

Privacy concerns about customer usage data and other personal data are real, but it is not clear how such data will be protected. Also, the installation of smart meters will open the door to remote involuntary disconnection and the use of service limiters, all of which limit customer access to and control over electricity service. Even unfounded concerns about a ―spy in the house‖ may affect consumer attitudes. Thus, issues related to consumer privacy will likely be submitted to regulators and consumer protection agencies as soon as new technologies are planned.

11) Regulations

No defined standards and guidelines exist for the regulation of smart grid initiatives in India. Regulatory overview is extremely important in case of smart metering system due to involvement of consumer data. Smart meters require new additions in metering regulations that already exist considering the new functionalities the system will bring along. Lack of strong regulations may hinder smooth functioning in the long run.

12) Consumer acceptance to increased bill with smart meters

The change-out of an existing meter is often a contentious issue for customers, especially when the new electronic meter registers a higher bill. A customer relations program is needed to alert customers to the upcoming meter change-out. It should spell out what the customer's rights are, explain the long-run benefits of smart meters, and describe how the change-out will be conducted.

13) Uncertainty about quantification of benefits to different parties

India is spread over vast geographical area with differing climatic condition and consumer behavior. So a generic model of benefits cannot be developed based on international or anticipated benefits. Actual benefit realization of the smart meter system can only be done after implementation of the project. This is a challenge for the researchers for implementation in India. The absence of robust empirical evidence regarding the performance and economics of AMI and dynamic pricing on a system-wide basis over time is a source of uncertainty over both long-term technical performance and the magnitude of peak load reductions that will actually be sustained in the long term in response to dynamic pricing.

14) Slow Decision making and implementation

One of the major hurdles in project development and implementation across various sectors in India is slow decision making. Indian grid is old and with advancement of new technologies and required capacity addition is slowly becoming redundant. However planning and research activities alone consume the maximum of time. Smart meter deployments are taking place at a very fast pace internationally. India should take a clue not only from developed countries as US but also developing countries as itself like Brazil.

3.4 Costs, Benefits & Risks for India

Smart Metering system will be different from the present system with greater consumer involvement and enhanced advantages and responsibility to the utility. Thus, project economics will need to reflect the benefits to both consumers and utilities.

A top-down review of a typical smart meter project reveals that a large capital outlay will usually be required to fund the various aspects of implementation. The primary costs will include automated metering infrastructure, customer systems such as in-home displays and digitally controlled appliances, and electric distribution and transmission system grid automation.

The primary benefits include lower operating and maintenance costs, lower peak demand, increased reliability and power quality, reductions in carbon emissions, expansion of access to electricity and lower energy costs from fuel switching and home automation.

3.4.1 Costs

The typical costs associated with the smart grid are categorized according to the elements and functions they provide. An approximate model of costs of these components is presented in the next chapter.

The major cost items are:

- **Cost of project design and feasibility studies**

The concept of smart metering is new to Indian context. Smart meter deployment programs have been in progress in a number of countries. Their strategies and practices can be analyzed and adopted for project planning and deployment. But the utilities and government would have to keep in mind the difference in the power sector scenario in India. Mostly, the smart meter deployment projects have taken place in developed countries as US, UK, Italy, Australia etc., their best practices can surely be studied for planning but a direct implementation of their strategy cannot be done. Developing countries as Brazil and China have also taken up Smart Meter deployment on large scale. An understanding from their perspective may prove useful for study. So, investment in project design and feasibility studies would be the inception costs the authorities would need to consider.

- **Cost of program management**

Smart meter deployment would be a large scale project requiring expert manpower to handle the deployment schemes and other project requirements. A detailed plan would need to set out for roll our strategy, consumer awareness, financing, benefit realization and utilization. So, a definite amount of cost will also be incurred on this aspect of project.

- **Meter, IHD and Communications capital cost**

There are different costs associated with meter, In House Display and communications infrastructure for the smart meter system. The cost of these hardware components of the system will depend on the functionality level the utility wants to incorporate.

- **Cost of installing the smart meters**

Costs of installing meter and communications systems will also need to be considered per meter installation.

- **IT Costs**

Smart metering system once deployed will change the relationship between the utility and the consumer. The smart metering system thus involves IT costs in form of IT system capital expenditure and IT system operational expenditure. The costs will also involve expenditure on communication data center costs.

- **Costs for customer information system**

This would include the cost to maintain and operate a consumer information system. A detailed information portal on consumer data shall have to be maintained by the utility.

- **Consumer Awareness costs**

Smart metering will bring along new concepts of two way communication and implementation ToU tariff scheme. The costs will be incurred to inform and educate consumers about the new system.

- **Operating and maintenance costs**

This would include costs to operate and maintain communication networks and hardware. These costs will depend on the technology solutions deployed. Determination of these costs on a certain basis can only be concluded after deployment.

- **Energy Cost**

Smart metering assets will consume energy and after analysis it has been observed that they will consume more energy than present systems.

- **Disposal Cost**

Costs to dispose of dumb meters as a part of roll shall need to be included in the costs. The costs should be reflective of the useful life left of the installed meters representing their Present Value.

- **Legal, marketing and Organizational costs**

Cost estimates for marketing and consumer support, legal costs and other setup (assurance, accreditation, tendering, trials, testing, data protection and security costs) and organizational costs.

- **Training and development of key staff**

With launch of a new metering system the utility staff will have to train to work efficiently on the new system. A thorough understanding of system benefits and risks should be known to the working staff. The regulatory bodies will also have to train their staff to be able to address any issues that may arise with new system development. Up gradation of system, system operation and maintenance, system security, consumer queries all propose the need to train the key staff involved.

3.4.2 Benefits

The move to a smart metering promises to change the power industry‘s entire business model and its relationship with all stakeholders, involving and affecting utilities, regulators, energy service providers, technology and automation vendors, and all consumers of electric power.

The smart grid envisages providing choices to every customer and enabling them to control the timing and amount of power they consume based upon the price of the power at a particular moment of time.

Some basic quantified benefits that will be accrued:

Consumer Benefits

- **Energy Demand Reduction**

There remains a great deal of uncertainty about the likely response of consumers to the full roll out of smart meters. A number of international studies exist; the most recent a review of 57 feedback studies in nine different countries by the American Council for an Energy-

Efficient Economy which finds that on average feedback reduces energy consumption between 4-12%. For Cost Benefit Analysis in Indian context the analyst would need to make approximation keeping in view domestic scenario and consumption pattern.

- **Energy Demand Shift**

Another potential source of change in consumption patterns through smart meters is a shift of energy demand from peak times to off-peak times. The rationale behind the underlying assumption is the benefit by Time of Use (ToU) pricing.

- **Micro generation**

This includes savings from using smart meters to deliver export information from micro generation devices. That may have to be done by estimating the number of micro generation devices that will be in use. A conservative estimate of number of units shall have to be made. However, micro generation as an effective concept would be built up in later stages of smart grid. It may not be integrated in a simple AMI project.

Business Benefits

- **Avoided site visits**

With smart metering system in place suppliers will not have to visit consumer‘s premises for meter reading or safety inspections, allowing savings on this front. Visits to go for meter reading again if premises are found locked, safety check visits, inspection visits will be redundant once smart meters will be installed. An approximation of these benefits will also need to be done to include as quantified benefits.

- **Customer Service overheads**

Call center cost savings as a result of a reduction in billing enquiries and complaints. Smart meters will mean an end to estimated bills and this is expected to result in lower demand on call centers for billing and other enquiries.

- **Remote switching and disconnection**

The meter functionality will enable remote enablement or disablement of the electricity supply. Direct benefits will be the avoided site visit and equipment up gradation costs. This functionality will help disconnect consumers leading to bad debts. Approximation on benefits by debt management shall also be included in benefits.

- **Theft**

  The implementation of smart metering could reveal existing theft and allow suppliers to combat it better. Estimating theft is problematic as by its nature theft levels are difficult to quantify. The amount of theft is likely to decrease as suppliers will have access to more accurate and frequent data and will detect theft more quickly.

- **Losses**

Smart meters are expected to reduce the loss levels which will have to be quantified for CBA.

- **Outage Management**

Availability of detailed information from smart meters will improve electricity outage management and enable more efficient resolution of network failures. Benefits identified are reduction in unserved energy (customer minutes lost), a reduction in operational costs to fix faults and a reduction in calls to fault and emergency lines.

- **Better informed investment decisions for electricity network enforcement**

By having more detailed information on locational peak demand, bottle necks in the network can be identified and enforcement investments can be better planned.

3.4.3 Risks associated with Smart Meter Project

Because of the lack of experience with the full-scale deployment of advanced metering infrastructure (AMI) and dynamic pricing, there are a number of uncertainties associated with projected benefits and costs.

- **Assessing the Impact of a Project's Scale and Complexity, and the Impact of Resources Constraints**

These uncertainties create a financial risk that the actual benefits from a smart meter plan may prove to be even less than the stated projections.

A number of AMI projects have not been approved in US and Europe due to the unclear projections and the lack of a contingency plan in case the utility becomes cash strapped. A recent example from US is the smart grid project by Xcel Energy in Colorado, where projected capital expenditures for the SmartGridCity went up from an initial estimate of $15.3 million in March 2008 to $27.9 million in May 2009. As of new updates, the company believes the total bill will reach $42.1 million, not including the costs of operating and maintaining the new grid.

A large part of the increased price tag is associated with the unanticipated difficulty of the scale and resources required in constructing the system‘s fiber network. Hence, it is important to plan in advance for unanticipated resource constraints while budgeting for a smart grid project.

- **The Effect of "Fast Tracking" on Project Schedules and Cost**

The rapid development of both the technologies and rate designs and related AMI functionalities makes the job of the system planner complicated and challenging. Best practices require that the designers of the hardware, software and communications networks engineer the system to a well-defined end-state of functionalities. When evaluating project costs, they must determine exactly what the information will do, and who needs it for what purpose, at what time.

Utilities in US have experienced difficulties because when they were attempting to fast track a project, they chose technologies that turned out not to have certain desired functionalities. Customers are paying incremental costs for functions that conceivably could have been integrated less expensively had the utility started with those specifications in mind before designing and bidding out its metering project. The continuing evolution of the smart grid presents challenges to system planners, especially at this early stage in its development.

Slow decision making and project development are inherent in Indian scenario. This flaw may prove to be more problematic with continuous technology evolution. Timely decisions to implement and upgrade the system are necessary for optimum results.

- **Anticipation of Consumer Response**

The costs of information technology integration and software are the largest component in a smart grid project. A utility attempts to recover this cost through smart pricing techniques, which help in peak load management, thus reducing the utility‘s cost of generation and service. The success depends on how proactively the consumers will respond to the new system. However, it is difficult to anticipate the consumer response. This may lead to a more complex; more complicated and, sometimes, somewhat convoluted cost-benefit analysis.

- **Accelerated depreciation of technology**

For many decades, once a utility plant was constructed or equipment installed, it could be reliably expected to remain in service for its estimated useful life. Many of these ranged from 10 to 40 years. Meters, for example, had useful lives of 10 to 15 years. However, advanced meters and metering systems employ computing technology. The technological and cost curves for computers may be very different from the equipment historically used in the electric utility industry. If advanced metering systems exhibit technological and cost behaviors that are similar to those of computers, then their useful lives may turn out to be shorter than estimated.

- **Risk of stranded assets**

Deployment of smart meter means replacement of already installed meter system in place. This clearly establishes the risk of creating stranded assets, as the smart roll-out could make them redundant before the end of their asset life. Scope of up gradation of present system should be examined to reduce on these costs.

The chapter defines the costs and benefits of smart meter deployment which may be quantified according to the concerned area of deployment and various socio-economic conditions prevailing. The next chapter deals with financing of the smart meter project.

3.5 Financing

Funds are one of the major roadblocks in implementation of Smart Grid. Policy makers and regulators have to make more conducive rules and regulations in order to attract more and more private players. While no one has estimated with any level of detail the costs required for India to upgrade to smart metering, estimates range widely depending on the utilities involved and the timing. Given the large investment required to build out the current set of plans, Indian utilities will need to experiment with how best to fund such projects. The Indian distribution sector‘s financial health has not been great. It is considered to be the most crippled of all entities in the power system. In such a financial condition self-financing by the utilities may not be possible, although of all the stakeholders, the utility will benefit the most from the smart metering system. With the present state of DISCOMs banks are not ready to assist financially. To get finances from the banks a strong cost benefit analysis in favor of the project shall have to be proposed by the utility. However, conducting a foolproof Cost Benefit Analysis in quantified terms shall not be possible without implementation of the project.

International assessments and experiences have proved the financial benefits smart metering systems will bring along. But those assumptions cannot directly be linked to Indian scenario. Benefits of the smart metering system can only be achieved eventually after efficient implementation of the system. With this situation arrangement of finances for the project cannot be done without government assistance.

Based on a survey, most utilities are proposing to recover all of these costs via a fully reconcilable surcharge. Many are proposing to allocate these costs among rate classes according to the number of customers in each class. Some utilities are also proposing to recover these costs via a monthly customer surcharge. But, this model has its own flaws. Low consumption customers may not benefit from the new system as much as high consumption consumers with them still paying equally. Regulatory bodies thus need to keep a check on this to preserve consumer interest.

Some possible alternatives for funding are presented below. However, these are only illustrative in nature. Detailed rounds of talks with government, banks and the private sector will need to be undertaken to rationalize and validate the plausibility of these alternatives.

For central sector lending, develop a new appraisal process for smart metering projects.

Grant and loan funding for the smart grid can come through traditional sources (e.g., PFC), but a revised project appraisal process that incorporates operational benefits will be needed to evaluate project submittals.

Reach self-funding.

Following the lead of on-going loss reduction projects, many smart meter projects will become self-funded by exceeding the stipulated payback periods.

Attract new players and bring in vendor financing.

Information and communication technology companies such as IBM, Infosys, and Wipro have started smart grid programs and are developing commercial models. Some examples of pilot projects include those with real estate developers to implement small-scale smart grid projects for residential and commercial complexes. The government may try to introduce incentive schemes to attract participation.

Expand bank understanding of the smart grid

Banks that are already lending to the power sector will see the business case for the smart meter quickly and can act to increase funding directly to projects, or indirectly to companies and utilities. The most prudent route is however, a combination of these sources through public private partnerships. State utilities can take the lead on developing the business case for pilot implementations of smart grids and then invite private players to participate by providing both technical know-how and funding. Private players can further approach the banks to fund their investment.

Given the financial state of the sector, funding of the project should be as such the risk is divided along the entire value chain. This may be done by assessing the benefits each stakeholder may achieve on deployment of smart meters.

Chapter 4

4. Smart Metering in India: Market Landscape

4.1 Market Landscape

4.1.1 Introduction

A smart grid is a modernized electrical grid that uses analogue or digital information and communications technology to gather and act on information, such as information about the behaviors of suppliers and consumers, in an automated fashion to improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity. A smart grid uses a smart meter to monitor energy consumption at consumer level.

A smart meter is usually an electronic device that records consumption of electric energy in intervals of an hour or less and communicates that information at least daily back to the utility for monitoring and billing purposes. Smart meters enable two-way communication between the meter and the central system. Unlike home energy monitors, smart meters can gather data for remote reporting.

The Benefits Provided by a Smart Meter:

To Consumers-

- Detailed feedback on energy use patterns and consumption
- Improved control over energy costs
- Accurate bills with no more reading errors

- Improved and increased pricing options
- Improved outage restoration
- Improved quality of data on power

To Utility Providers-

- Elimination of manual meter reading
- Quick monitoring of electric systems
- Efficient use of power resources
- Real-time useful data for balancing electric loads and reducing power outages
- Better capacity planning
- Dynamic pricing based on demand

To the Environment-

- Reduced consumption and efficient distribution to reduce wastage
- Reduced consumption from increasing power generation

Although India is one of the fastest-growing economies in the world, its industrial growth has been limited by inadequate energy availability. India ranks sixth in terms of worldwide electricity consumption, yet reportedly suffers from electricity transmission and distribution losses of around 30 percent and a mismatch of supply and demand in electricity of approximately 12 percent. Large companies operating in India often build their own power plants to ensure a reliable supply of electricity, due to frequent blackouts and an inefficient electric supply. Further, a large segment of India's rural population has no access to electrical services.

There is no doubt of the potential benefits of smart metering for commercial process improvements e.g. faster meter reading and revenue management, customization of customer load requirements, fulfillment of regulatory requirements for energy efficiency, customer awareness for energy uses and energy cost saving.

4.1.2 Market Size and Forecast of Smart Meter Market in India

According to the U.S. Energy Information Administration (EIA), 404 million people in India currently do not have access to electricity. In the report, "India: Smart Grid Legacy", the researching company, Zpryme indicates that in 2015 India's smart grid market will be $1.9 billion with the country's basic electrical infrastructure needs will grow beyond that, totaling $5.9 billion in the same year.

India's transmission grid is in urgent need of expansion and improvement. According to industry sources, utilities worldwide will spend US$ 378 Billion in Smart Grid technologies by 2030 and India, the third largest smart grid investment market, is set to install 130 million Smart Meters by 2021.

India is running pilot projects at the moment. The details of these are mentioned below:

Table 4 India is running pilot projects at the moment

Electricity Board	State	Location (City/Region)	No. of Consumers	Allocated Budget (Rs. Cr.)
Chamundeshwari Electricity Supply Corporation Ltd. (CESC)	Karnataka	Mysore Additional City area	21,824	32.59
Andhra Pradesh Central Power Distribution Company Limited (APCPDCL)	Andhra Pradesh	Jeedimetla area of Hyderabad	11,904	41.82
Assam Power Distribution Company Limited (APDCL)	Assam	Guwahati	15,000	29.94
Uttar Gujarat Vij Company Ltd. (UGVCL)	Gujarat	Naroda and Deesa	20,524	48.78
Maharashtra State Electricity Distribution Company Limited (MSEDCL)	Maharashtra	Baramati Town	25,629	28.21
Uttar Haryana Bijli Vitran Nigam Limited (UHBVNL)	Haryana	Panipat	31,914	20.07
Tripura State Electricity Corporation Limited	Tripura	Agartala town	46,071	24.08

(TSECL)				
Himachal Pradesh State Electricity Board (HPSEB)	Himachal Pradesh	Kala Amb	650	17.84
The Electricity Department of Government of Puducherry	Puducherry	Puducherry	87,031	46.11
Jaipur Vidyut Vitran Nigam Limited (JVVNL)	Rajasthan	Vishwakarma Industrial Area, Jaipur	34,752	33.38
Chhattisgarh State Power Distribution Company Limited (CSPGCL)	Chhattisgarh	Siltara in Raipur District	508	5.55
Punjab State Power Corporation Limited (PSPCL)	Punjab	Amritsar	9,818	10.11
Kerala State Electricity Board (KSEB)	Kerala	Selected 79 Distribution Section offices	25,078	27.58
West Bengal State Electricity Distribution Company Limited (WBSEDCL)	West Bengal	Siliguri	4,404	7.03
Bangalore Electricity Supply Company	Karnataka	Bangalore	63,058	NA
Odisha-Ganjam Dist(Disaster Resilient Power Strengthening System)	Odisha	Ganjam	NA	1000.00
Odisha-smart grid pilot project	Odisha	NA	NA	NA
West Bengal SEDC-Garia(Kolkata)	West Bengal	Kolkata	50,000	300.00-350.00

4.1.3 Smart Meter Market In India Compared To The World

GTM Research forecasts the cumulative value of the smart grid market to surpass $400 billion by 2020, growing with an average compound annual growth rate of over 8%.

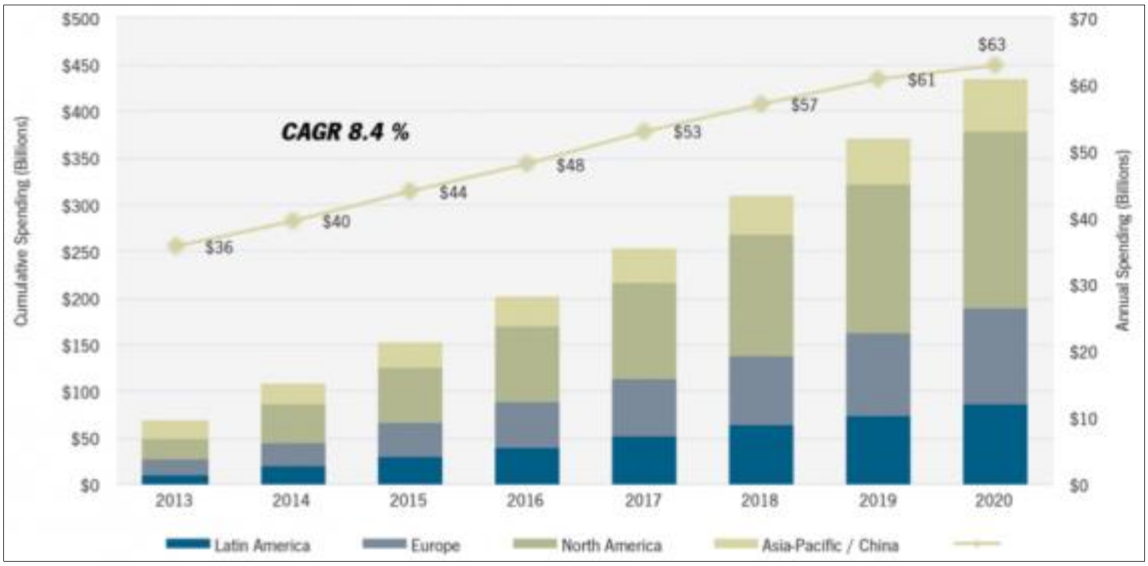


Figure 9 Global Market for Smart Grid Equipment

According to one industry source, the global market for smart grid equipment and services was valued at approximately $60 billion in 2013, a figure that is expected to rise to more than $400 billion by 2020.

The global smart meter market has been growing significantly in recent years. Worldwide, the market for smart meters was valued at approximately $4 billion in 2011, and is expected to grow to an estimated $20 billion by 2018. The largest markets have been North America, Europe and eastern Asia (particularly China). The global market is projected to continue expanding as countries that have yet to adopt smart grid technology begin to do so, and as large rollouts that have been delayed—most notably in the United Kingdom and France—move forward.

India ranks third in the world for smart grid investment, after the United States and China.

A number of U.S.-based firms are among the world's leading producers and are actively supplying the leading foreign markets, principally by manufacturing in or close to those markets.

Table 5 Smart Meter Deployment in India compared to the rest of the world (as on 31/03/2014):

Country/ Continent	Total number of meters currently deployed (in mln)	Number of Smart Meters already deployed (in mln)	Smart Meters as share of total deployment (%)
USA	150.0	46.0	30.7
Europe	281.0	61.2	22.0
Australia	9.5	3.0	31.6
Canada	15.0	7.3	49.0
India	200.0	-	<<1.0

4.1.4 Key Drivers and Challenges

Government policy mandates and fiscal incentives have been the primary drivers of demand for smart electricity meters in a multitude of markets, and tend to attract manufacturers that are seeking to expand their global presence.

The key drivers for smart metering are enumerated in brief as follows:

1. Need for reduction in meter reading and revenue realization cycle
2. Curbing fraudulent practices
3. Need for reduction of peak demand through systematic load reduction
4. Assistance in reduction in grid failure
5. Technical and Commercial Loss reduction
6. The new technologies will improve the usefulness and granularity of demand-side management and demand response programs in terms of better customer segmentation and other benefits
7. Lack of cross-departmental data sharing capabilities

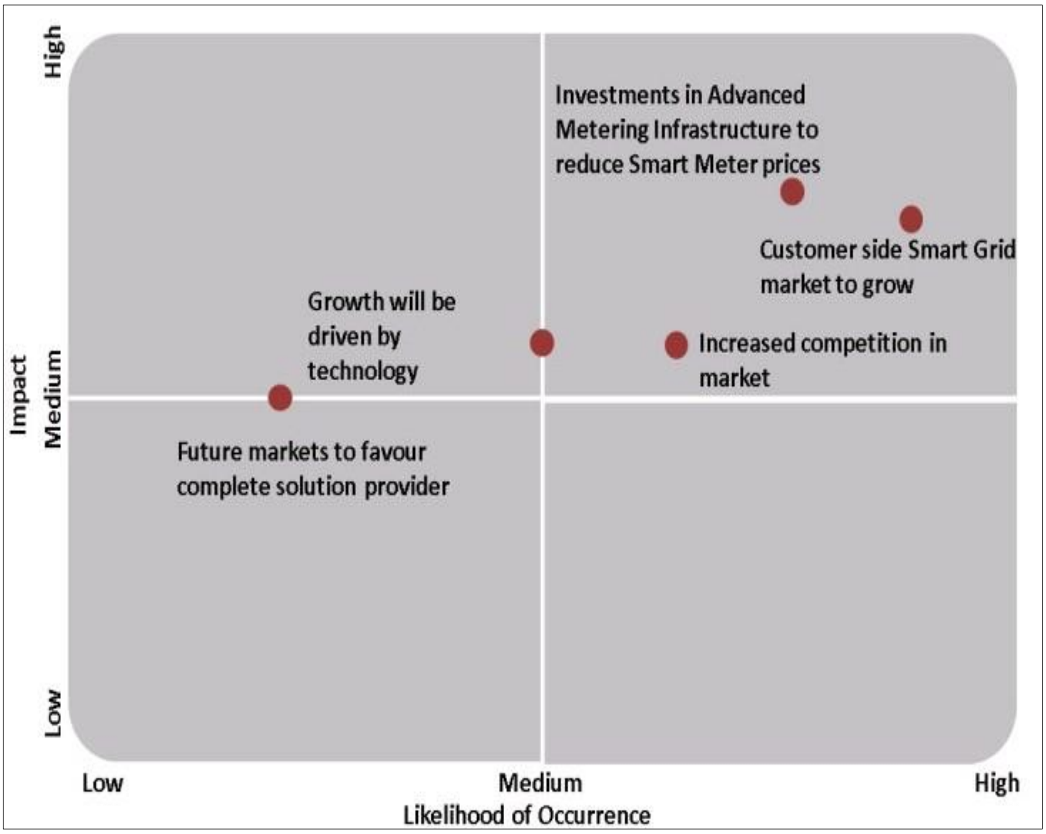
Worldwide, most countries share common challenges when it comes to energy: demand is rising, while security and environmental concerns are changing the way that energy is generated and distributed. As a result, utilities around the world are seeking more efficient, reliable, and secure ways to manage energy generation, transmission, and distribution. The "smart grid" has emerged as an effective approach to aligning the supply of energy in a given market with demand, while reducing waste.

The challenges that limit the scope of mass scale implementation of smart meters are described in brief as follows:

1. It’s a new initiative and there are no sufficient information or data to justify the end benefit of this high cost metering
2. This is very costly and time consuming process which requires significant capital expenditure
3. Utilities have already spent a sizable amount for upgradation of the existing electromechanical or old static meters, therefore, reinvestment for smart metering will be difficult at the Regulator as well as utility perspective
4. Absence of associated infrastructure for meter data analysis and necessary action for pilferage reduction
5. Insufficient regulatory focus and policy on smart metering
6. Lack of consumer awareness on Smart Grid concepts, how they will be benefited through Smart metering
7. Availability of limited RF spectrum
8. Security concerns especially balancing firmware upgradability with usability

4.1.5 Key Trends And Developments

Trends in the Indian Smart Grid Space: Impact and Likelihood of Occurrence



Key Trends and New Developments in the Smart Meter market space:

- The India Smart Grid Task Force (ISGTF), an inter-ministerial group that serves as a government focal point for all activities related to smart grid technology, formed a Smart Meter Task Force in March 2011 to advocate for the development of cost-effective smart meters in India. The task force advised the government that India needs 100 million low-cost smart meters, priced between Rs.1,000 and Rs.1,500 ($16–$25) per meter, in order to feed critical data into the smart grids. This price is considerably lower than the average price of a smart meter in the United States.

- Indian's regional governments rely on both domestic and foreign manufacturers to supply the smart meters for these initiatives. For example, in India's largest smart meter order to date, Landis+Gyr was chosen by the West Bengal State Electricity Distribution Company to supply 1.5 million smart meters to the city of Kolkata by November 2013.

- Most pilot projects are focusing on reducing Aggregate Technical and Commercial (AT&C) losses.

- Deployment of more Advanced Metering Infrastructure (AMI) meters than Automatic Meter Reading (AMR) meters is expected as India is already lagging behind compared to the world when it comes to smart meter deployment.

- The implementation of Public Private Partnership (PPP) model can provide incentive for private players in working in the segment meant to reduce AT&C losses.

- PPP models are used in making Smart Grid implementation more viable by bundling other utility services like cable TV, gas, water, etc.

- IBM has been selected by Tata Power Delhi Distribution to conceptualize, design, and deliver an advanced Smart Grid solution that will collect and analyze real-time information from Smart Meters and data from the communication and management infrastructure.

- HCL has partnered with eMeter (smart meter manufacturing firm) and Tridium (data management and communication solutions firm) to accelerate its strategy to become an end-to-end integration services provider to the utilities.

- Landys+Gyr have set up manufacturing units in India at Baddi in Himachal Pradesh and Joka in Kolkata, West Bengal.

- Elster Metering have set up manufacturing units in India at Daman and Mumbai.

- Localization trends may pose problems for vendors to varying degrees. Reportedly, several prominent foreign markets exhibit preferences for local providers, particularly in China, Eastern Europe, India, Japan, and Korea.

- Retro-fit metering solution is generating good interest in India as well as in Brazil

4.1.6 Government Regulations and Regulatory Requirements

Governments typically have been the principal drivers of growth in the global market for smart meters through mandated use and incentives. In fact, according to one industry assessment of global smart grid projects, government investment propelled nearly all of the initiatives identified across Europe and in seven individual countries. Once installed, smart meter technology usually results in savings for both utilities and consumers, but most utilities are reluctant to invest in the new technology without a government mandate or incentive to do so. Utilities tend to have limited budgets for capital expenditures, and smart meters are among many competing demands for those resources. Further, utilities may not realize the benefits from smart meter installation for several years, making the investment less attractive in the absence of government incentives.

Several countries have enacted legislation mandating adoption of smart meters as part of broader clean energy initiatives. In 2008, for example, the United Kingdom mandated that 53 million smart electric and gas meters be deployed in homes and businesses by 2019.

The India Smart Grid Task Force (ISGTF), an inter-ministerial group that serves as a government focal point for all activities related to smart grid technology, formed a Smart Meter Task Force in March 2011 to advocate for the development of cost-effective smart meters in India.

The Ministry of Power, India developed draft specifications for single-phase smart meters in 2012. In the same year, the India Smart Grid Forum—a public-private partnership consisting of utility companies, industry, academics, and other interested parties—released plans calling for smart meters to be the norm for all new connections by 2017.

Though the central government's advocacy has helped to promote the technology, regional governments reportedly have been the most proactive in actually implementing smart meters programs.

Ministry of Consumer Affairs has issued a list of Indian Standards under mandatory certification for various industries and in this list for electricity measurement and billing, IS 13779 and IS 14697 have been made mandatory. MoP may request Ministry of Consumer Affairs to amend this list with the inclusion of new smart metering standards that will be issued by Bureau of Indian Standards on fast-track. Till such time a waiver for compliance under this mandatory list may be sought so that installation of smart meters under the pilot projects can progress uninterrupted.

Most importantly, all new meters must not only be digital/static, but smart ready even if they are not smart meters. This simply ensures that data formats/structures/APIs, and the communications ports/protocols are standardized.

4.1.7 Technology and Financing - Current Situation And Issues

India is heavily dependent on non-renewable sources of energy (coal, gas, etc.) due to shortage of funds for investment. Renewable sources of energy like solar, wind, tidal, etc. are not harnessed at a very significant level. The technology infrastructure used to supply electricity is ageing and stretched in many cases in an unplanned way with the aim of providing immediate short term solution. The renewable sources of energy generated are not well integrated with the main electricity grid. There is high entry barrier.

It is also observed that 45% of electricity is consumed by industrial sector, 27% is used by agricultural sector and 16% is used for residential requirements and the rest by other sectors. There is an official estimate of about 28% Aggregate Technical and Commercial loss (AT&C) and there is still an official estimate of 36% of total population still awaiting access to electricity.

State power plants contribute about 48% of the total installed power capacity but the state electricity boards suffered a combined cash loss of about 1.5% of India's GDP in 2009. It has been observed that 40% of this loss was caused due to technical loss and 60% was due to commercial loss. The main causes of commercial losses are power theft, pilferages and low metering efficiency. As a result, there is dire need for reforms in the power sector. Moreover, it may not appear viable for such state electricity boards already crunched of funds to inject funds for system upgradation and migration to Smart Grid Technology as well as creating new jobs for executing, supervising and maintaining this technology.

The implementations of smart grids are currently being carried out with the help of private players providing hardware, software and consulting under Public-Private partnership (PPP) model. However, there is an absence of smart grid Eco-system to collectively provide hardware, software and consulting in India; this may deter migration and adoption efforts to Smart Grid solutions.

The India Smart Grid Task Force (ISGTF) an inter-ministerial group initiated by the Ministry of Power, has been serving as a government focal point for all activities related to smart grid. Under the ISGTF, in March 2011, a Smart Meter Task Group was formed to discuss the development of cost-effective metering solutions that can be applied within the Indian context.

Smart Grid Technology includes within itself components of power sector, telecommunications sector and IT sector. There are different regulatory authorities for these sectors. As a result, there is a need for clear framework and regulatory policy guidelines for domestic and international entrants in this segment for transparency and better service to end customers. There is a need to implement cyber defense strategy on smart grids against cyber criminals, terrorist organizations and rival nations before their full scale roll out in India.

4.1.8 Smart Building/Smart City Activities and Forecast In India

The concept of smart city has been introduced as a strategic device to encompass modern urban production factors in a common framework and to highlight the growing importance of Information and Communication Technologies (ICTs), social and environmental capital in profiling the competitiveness of cities.

A city can be defined as ‘smart’ when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic development and a high quality of life, with a wise management of natural resources, through participatory action and engagement.

To accommodate rapid urbanization, the Government of India has allocated US$ 1.2 billion in fiscal year 2014-15 to build 100 new smart cities, and to develop satellite towns around existing cities. Most other funding will come from Indian and overseas private sector companies.

The government plans to deliver three smart cities by 2019, all of which will be part of the larger project called Delhi-Mumbai Industrial Corridor (DMIC). These smart cities, scheduled to be completed by 2019, are Dholera, Shendra-Bidkin and Global City.

The cities with ongoing or proposed smart cities include Kochi in Kerala, Ahmedabad in Gujarat, Aurangabad in Maharashtra, Manesar in Delhi NCR, Khushkera in Rajasthan, Krishnapatnam in Andhra Pradesh, Ponneri in Tamil Nadu and Tumkur in Karnataka. Many of these cities will include special investment regions or special economic zones with modified regulations and tax structures to make it attractive for foreign investment.

Cisco has already signed an agreement to transform Bangalore Electronic City into a smart city in partnership with Electronics City Industries Association. SmartCity Dubai plans to tie up with the Madhya Pradesh government for a similar project to be located between Bhopal and Indore.

Outside Mumbai, the Lodha group has given IBM a contract to build all data systems in their Palava city project. Kochi has a special economic zone that seeks to replicate Dubai's smart city project. Gujarat has two projects, the Dholera urban area, which is part of the Delhi-Mumbai industrial corridor, and the Gujarat International Finance Tec-City, both of which have problems but are being touted as examples that could be scaled up across the country.

4.2. Vendor Landscape

Localization trends relating to radio communication bands, mesh technology, broadband, etc. may pose problems for vendors to varying degrees. Reportedly, several prominent foreign markets exhibit preferences for local providers, particularly in China, Eastern Europe, India, Japan, and Korea. However, while local-content requirements do exist in a few countries (e.g., in Brazil, Mexico, and Taiwan), industry representatives did not consider them to be a pervasive global problem. In Korea, some local policies require inputs that are only available locally for manufacturing smart electricity meters.

4.2.1 Key Players in India

Key players and their area of expertise in Smart Grid technology segment:-

Table 6 Key players and their area of expertise in Smart Grid technology

Technology Area	Brief of Companies	Select few Players	
IT Firms/System Integrators and Consulting	• Networking Data Management Companies • System Integrators • Energy And IT Consultants • Energy Services Firm	Accenture	NDPL
		Infosys	HCL
		Capgemini	Power Grid
		KEMA	HP
		CMC India	TCS
		IBM	Telvent (Schneider)
	• Communications hardware and Software firms • Supplies of sensors and products for AMI	Analogics	Hughes
		Cisco	Linkwell Telesystems
		Echelon	Siemens
		Ericsson	Tata Communications
		GE	Texas Instruments
Meter Hardware	• Smart Meter Manufacturing Companies • Meter Data Management • Systems (MDMS) companies	eMeter	Itron
		Elster Metering	Lands+GYR
		EMCO	Secure Meter
		GE	
Energy Management Service	Companies that provide automation, monitoring and control systems	ABB	Schneider
		Johnson Controls	SNC Lavalin
		Honeywell	

Recent Activities of Key Players:

CISCO

- Cisco is the largest supplier of communication products in the world
- Cisco considers Smart Grid as the next big thing and visualizes Smart Grid emergence similar to the emergence of the Internet

- Through its Smart Grid ecosystem, it plans to develop Smart Grid Technologies and standards by collaborating with Smart Grid stakeholders. It has roped in participants like Infosys, Itron, Schneider, etc. to create a Smart Grid ecosystem
- It recently launched Smart Grid products: Connected Grid Router (CGR 2010) and Connected Grid Switch (CGS 2520)

IBM

- IBM has been selected by Tata Power Delhi Distribution to conceptualize, design, and deliver an advanced Smart Grid solution
- that will collect and analyze real-time information from Smart Meters and data from the communication and management
- infrastructure
- IBM has collaborated with India’s Bureau of Energy Efficiency to create a cost benefit analysis of setting up Smart Grids in the country
- IBM has experience of more than 150 Smart Grid projects worldwide, and anticipates that India has an emerging market. It is developing products and solutions to match the Indian market and plans to collaborate with other industry stakeholders

HCL

- HCL has partnered with eMeter (smart meter manufacturing firm) and Tridium (data management and communication solutions firm) to accelerate its strategy to become an end-to-end integration services provider to the utilities
- HCL has set up two Smart Grid labs in India and has the advantage of working with the public sector as consultant and IT-IA for R-APDRP projects

eMeter

- eMeter is gaining prominence in the Smart Grid field in India because of its association with system integrators and IT firms
- eMeter is currently associated with IBM, HCL, Accenture, Siemens, etc

Telvent

- Telvent is a leading IT software and automation solution provider in the Smart Grid industry
- Telvent has recently merged with Schneider Electric to provide complete Smart Grid solutions along with its existing range of automation products and automation solutions
- Telvent is implementing a Smart Grid project in Maharashtra in association with L&T

Other Firms

- GE is associated with NDPL for outage management systems and advanced geospatial information Systems
- Cyan is implementing Smart Meter solutions in the Puducherry Pilot Project
- TCS is a very active player in the public sector and has been awarded IT-IA for 13 states under R-APDRP; actively seeking collaborations with the other industry stakeholders

4.2.2. Type of Players in India and Their Comparison

Table 7 Type of Players in India and Their Comparison

#	Company	Headquarter	Services Offered			Products		Projects	Presence (Nations)
			EMS	M H/W	S/W	Res.	Comm.		
1	**GE**	Fairfield, CT, USA						Collaboration with NDPL in providing outage management systems and advanced geospatial information system; investing in Atria Power's wind farm in India	>17
2	**eMeter**	Foster City, CA, USA						NA	NA

3	**Elster Metering**	Raleigh, North Carolina,USA						NA	>13
4	**Itron**	Liberty Lake, WA, USA						Collaboration in supplying 150,000 units of smart meters for water supply purpose for Municipal Corporation of Greater Mumbai	>10
5	**EMCO**	Mumbai, MH, India						Collaborated with Grinpal Energy Mgmt. (South Africa) in installing smart meters in areas served by Tata power in Delhi around 2005. Grinpal Energy Mgmt was the technology support partner.	>=5
6	**Landis+GYR**	Zug, Switzerland						Collaborating with WESEDCL for supplying meters	3
7	**Secure Meter**	Gurgaon, Haryana, India						NA	>5
8	**ABB**	Zürich, Switzerland						Initiative in participating with PGCIL in worlds largest WAMS project; ABB collaborated in delivering SCADA project across Karnataka	>=10
9	**Johnson Controls**	Milwaukee, WI,USA						NA	>15
10	**Honeywell**	Morristown, NJ,USA						NA	>9
11	**Schneider**	Rueil-Malmaison, Île-de-France, France						Schneider Electric has secured contracts to execute the smart grid projects in Kerala, Bihar, Orissa and Jammu and Kashmir.	N
12	**SNC Lavalin (GE)**	Montreal, Quebec, Canada						NA	N (Acquire by GE

13	**Maven systems**	Pune, MH, India						NA	N/
14	**Kalkitech**	Washington DC, USA						collaborating with PGCIL to provide software required for smart grid implementation in Puducherry	>7

Key: - EMS-Energy Management Service, M H/W- Meter Hardware, S/W- Software, Res.- Residential, Comm.- Commercial. The cells with "x" indicate positive value

Industry Collaborations in Smart Grid End-To-End Solution Deployment

Collaborations	
IBM + NDPL	NDPL being a private distribution company and also a utility consultant hired IBM for Smart Grid projects in Delhi region.
Siemens + Accenture	Collaborated at global level and will be leveraging each others experience in Smart Grid industry
CISCO + itron + Schneider	Cisco replicating its global strategy to form a Smart Grid Ecosystem to provide end-to-end solutions
Telvent is now Schneider	Telvent merged with Schneider electric to provide complete automation solutions for Smart Grids
eMeter + Tridium	eMeter (Siemens) and Tridium compliment the services of one of the IT service provider and form a complete solution provider for smart grid projects.

4.2.3. Value Chain Analysis and Operating Model

In most European countries the utility network operators are responsible for the roll-out of smart meters to their customers. The main exception to this is the UK where the roles of network operations and energy retailing are separate. The energy retailers are responsible for the UK smart meters roll-out. The split of responsibilities in the UK could create an opportunity for infrastructure funds as energy retailers are unlikely to want to fund all of the capex required for a rapid roll-out of smart meters. The overall smart meters value chain extends from provision of hardware through to a range of systems and services. The majority of the cost of rolling out smart meters relates to the smart meters themselves and the corresponding deployment services.

Overview of the value chain steps:

- Equipment: Smart meters combine an electricity, gas or water meter with a communication module which enables communication over a network with the utility / energy service provider. The meter market is dominated by a few large, long established, international groups such as Itron, Elster and Landis+Gyr. Some smaller specialized companies are active in the network equipment market. The network infrastructure is likely to differ significantly across Europe.

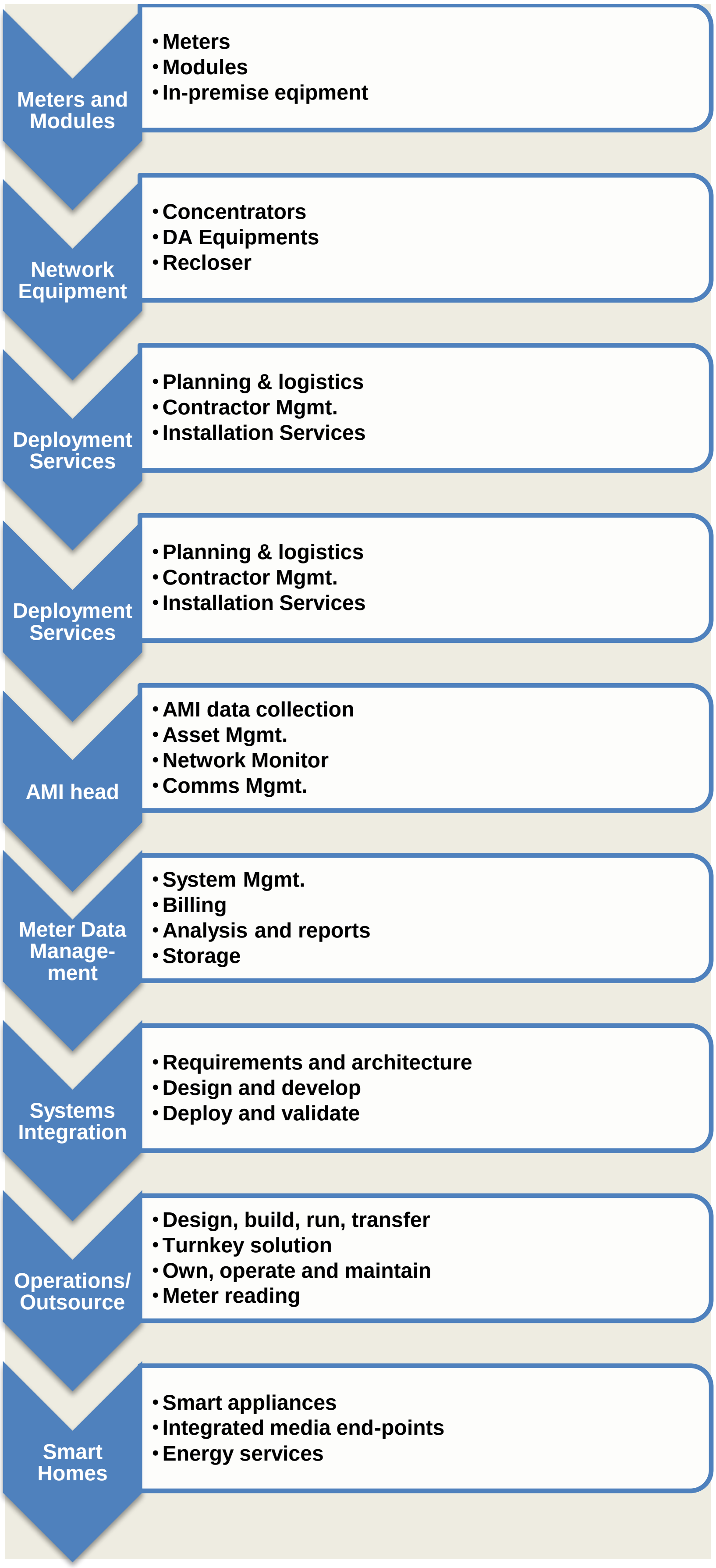
- Deployment services: Smart meter deployment services are often outsourced to specialized project management companies or system integrators.

- AMI head and MDM: The smart meter data flows to the AMI head which carries out meter data collection, network management and monitoring. The raw data is then passed to the meter data management (MDM) system for processing. Companies offering MDM systems include large software houses (e.g., Oracle), integrated meter manufacturers (e.g., Itron) and smaller specialized software companies (e.g., eMeter)
- System integration: The integration of smart meter systems into the operating systems of the utilities (or energy retailers) is mainly done by large international system integrators.

- Operation / Outsource: Network operations are traditionally carried out by utilities, however some activities are often outsourced.

- Smart homes: The smart homes market comprises a range of products and services which enable home automation and energy management – for example, appliances which can be turned on and off remotely to respond to changes in the network supply / demand balance. Companies active in the smart homes market include telecoms, utilities and internet companies such as Google and Microsoft.

Table 8 The Value Chain may be represented as follows:


Meters and Modules
Meters
Modules
In-premise eqipment
Network Equipment
Concentrators
DA Equipments
Recloser
Deployment Services
Planning & logistics
Contractor Mgmt.
Installation Services
Deployment Services
Planning & logistics
Contractor Mgmt.
Installation Services
AMI head
AMI data collection
Asset Mgmt.
Network Monitor
Comms Mgmt.
Meter Data Manage-ment
System Mgmt.
Billing
Analysis and reports
Storage
Systems Integration
Requirements and architecture
Design and develop
Deploy and validate
Operations/ Outsource
Design, build, run, transfer
Turnkey solution
Own, operate and maintain
Meter reading
Smart Homes
Smart appliances
Integrated media end-points
Energy services

4.2.4. Opportunities for New Entrants

Utilities' Three Primary Domains for Analytics:

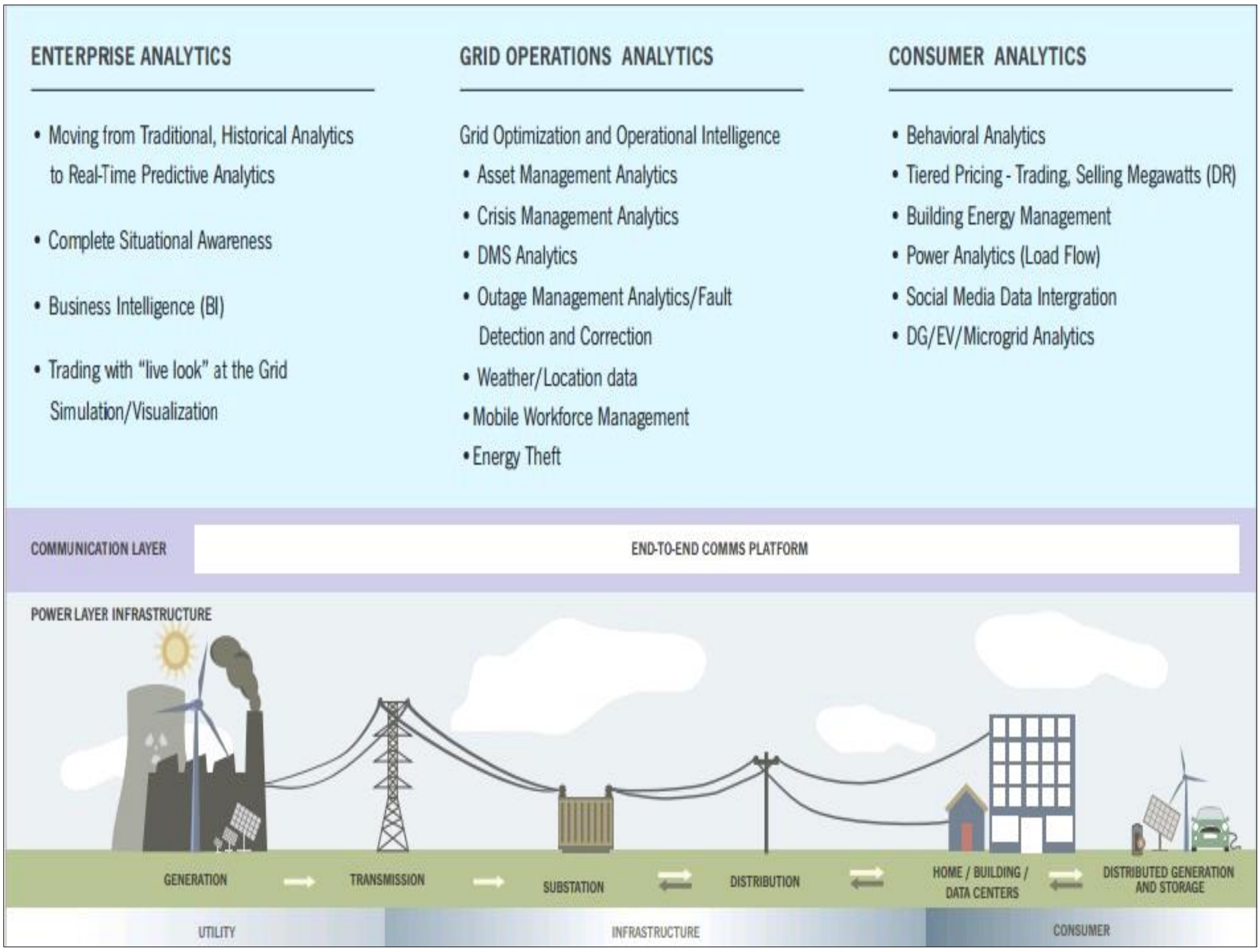


Figure 10 Three Primary Domains for Analytics

There are various ways to enter the Smart Meter market as explained in the diagrams above and below. However, due to the nascent stage of the Indian market, the entry point for a reseller seems to be through a Energy Management Solutions firm. As per statistics, reselling of the smart meter in India occupies about 5% of the smart meter market as on 2013.

Table 9 key technology areas identified from an opportunity perspective:

Technology Area	Hardware	Systems & Software
Wide-area Monitoring and Control	Phasor Measurement Units (PMU)	Supervisory Control And Data Acquisition (SCADA)
	Other sensor equipment	Wide Area Monitoring Systems (WAMS)
		Wide Area Adaptive Protection, Control and Automation (WAAPCA)
Information and Communication Technology Integration	Communication equipment (Power line carrier, WiMax LTE, RF mesh network, cellular)	Enterprise Resource Planning (ERP)
	Others: Routers, relays, switches, gateway, computers (servers)	Customer Information System (CIS)
Transmission Enhancement	Superconductors	Network Stability Analysis
	FACTS	Automatic Recovery Systems
	HVDC	
Distribution Grid Management	Automated Reclosers	Geographic Information System (GIS)
	Switches and Capacitors	Distribution Management System (DMS)
	Remote-controlled Distributed Generation and Storage	Outage Management System (OMS)
	Transformer Sensors	Workforce Management System (WMS)
	Wire and Cable Sensors	
Advanced Metering Infrastructure	Smart Meter	Meter Data Management System (MDMS)
	In-home Displays	
	Servers and Relays	
Electric Vehicle Charging Infrastructure	Charging Infrastructure	Energy Billing
	Batteries	Smart Grid-to-Vehicle Charging (G2V) and Discharging Vehicle-to-Grid (V2G)
	Inverters	
Customer-side Systems	Smart Appliances	Energy Dashboards
	Routers	Energy Management Systems
	In-home Display	Energy Applications for Smart phones and Tablets
	Building Automation Systems	
	Thermal Accumulators	
	Smart Thermostat	

Chapter 5

5. Challenges, Concern & Recommendation

5.1 Challenges: Smart Meter Implementation

5.1.1 Challenges to the Utility

- **Transitioning to new technology and processes**

Smart meter deployment would lead to a massive shift to new technology and processes. Smart meters differ from the older generation electromechanical or electronic meters on various technological grounds. Smart meters record a host of consumer information and communicate the same to utility in specified intervals of time. The recording and billing process would thus completely change on adoption of smart meters. The utility would thus need to make adapting changes in its MBC (Metering, Billing and Collection) process. It may require making changes in the existing metering infrastructure or even complete overhaul of the metering system and practices. The utility would thus also need to carry out interoperability studies. This shift would require huge investment on technology and infrastructure. The utility would thus need to carry out feasibility studies to analyze the costs and benefits of new system to make the transition smooth.

- **Managing public reaction and customer acceptance of the new meters**

Smart meter roll out in U.S and U.K garnered a lot of opposition from consumers on grounds of higher energy bills, loss of privacy and threat from Radio Frequency.

Residents have complained that the smart meters spiked their utility bills. Angry homeowners have accused the meters of gross inaccuracy, blaming them for monthly bills that almost doubled. Following on this customers filed formal complaints with the State Public Utility commissions. California regulators have had to launch an independent investigation that will subject the devices to a battery of lab and field tests.

Another issue raising problem in smart meter deployment is consumer concern over health hazards of smart meters. Studies by authorities in U.S have however shown that these signals are of much lower strength than those released from other common devices at home. The utilities and government should thus conduct studies and bring it to consumer notice to avoid such protests.

Lastly there is the consumer issue of privacy. Consumer concerns over privacy and loss of metered data to malicious third parties is raising alarm from consumers. With smart metering utilities would be able to monitor and read consumer power usage from central control point. Some consumers argue that the utilities can gauge the behavior of building occupants via the information collected, and that the utility‘s security can be hacked, jeopardizing their privacy. So, authorities must first have to develop flawless systems before deployment on large scale.

- **Smart meter hacking by consumers**

Smart meter hacking by consumers themselves, former employees of meter manufacturers, hackers or fraud utility employees is being seen as a big threat by government and utilities. It reports seeing an increase of smart meter hacking which allows "power theft" by consumers who want free electricity. In fact, hacking smart meters does not require mad skills, only modest hacking skills or hiring it done for a modest fee. Individuals with only a moderate level of computer knowledge are likely able to compromise meters with low-cost tools and software readily available on the Internet. Former employees of the meter manufacturer and employees of the utility were altering the meters in exchange for cash and training others to do so. They are employing tools that do not require removal, alteration, or disassembly of the meter, and leave the meter physically intact.

The utility must first carry out studies and make the system more reliant to avoid such frauds as hacking of smart meters on consumer will defeat the whole purpose of smart meter deployment and would in turn cause more loss to the utility.

- **Making a long-term financial commitment to the new metering technology and related software**

Adoption of smart meters would require a considerable amount of investment by utilities to develop new technologies and related software. Building up on the security of the smart meter system would itself require a huge investment on R&D. To continue with technology of smart metering the utilities will have to make financial commitment for the same as it would require continuous up-gradation and maintenance by utilities. Considering the financial condition of the Indian utilities this decision of investment in smart metering and the level of smart metering technology to be adopted has to be a very thought over decision. Financial constraint would be a major roadblock for Indian utilities to adopt this technology.

- **Managing and storing vast quantities of metering data**

Smart meters record and store a host of consumer power usage information.

The additional volume of data due to smart grids (which accounts for the bulk of data volumes) has been estimated by the ENA and Engage Consulting (U.K) to be up to two times greater than that associated with consumption data. This is based on a mixture of use cases (planning, load management, diagnostics, etc.) with bulk data downloads on a quarterly basis and a number of infrequent meter interrogations/alarms. For reference the "base case" meter traffic for electricity in smart grids is 60 terabytes per annum. By way of context one cellular operator in the UK reported a 2010 monthly average of 436 terabytes.

The utilities would have to firstly put in place Meter Data Management systems to store and manage the information recorded by smart meters. A thorough study and investment analysis by the utilities will have to be carried out before deployment.

- **Interoperability**

The interoperability functional requirements will have to be set out the minimum levels of technical interoperability of the smart metering system. The utilities should aim to develop smart meter systems on open standards for smooth and easy interoperability of the system. Interoperability is even more important in Indian context. The financial health of the utilities is not very good and thus developing interoperable systems would be a financially wise step for the industry.

5.1.2 Challenges to consumers

- **Verifying that the new meter is accurate**

Consumers across US and UK have raised voice against high electricity bills after installation of smart meters in their premises. Investigation teams were then formed by the concerned authorities to study the accuracy of the meters. The investigation studies proved that the meters were accurate. But to convince the consumer of accuracy of the meters is a task for the authorities. Also, the investigation and its process should be transparent for consumers to know the authenticity of the study. For consumer interest there should be a fair and transparent third party meter testing agency to carry out tests in case consumer sees foul.

- **Protecting the privacy of their personal data**

Current smart meter technology allows utilities to measure usage as frequently as once every minute. By examining smart meter data, it is possible to identify which appliances a consumer is using and at what times of the day, because each type of appliance generates a unique electric load signature. As smart meter technology develops and usage data grows more detailed, it could also become more valuable to private third parties outside of the grid. Data that reveals which appliances a person is using could permit health insurance companies to determine whether a household uses certain medical devices, and appliance manufacturers to establish whether a warranty has been violated. Marketers could use it to make targeted advertisements. Criminals could use it to time a burglary and figure out which appliances they would like to steal. Such continuous and detailed monitoring of consumer usage is being seen as threat by consumer. Security threat and privacy loss is a major concern for consumers. Considering this issue, smart meter deployment is seeing a lot of opposition from consumers.

- **Paying additional fees for the new meter**

The cost incurred by utilities on smart meter deployment would gradually be charged on to consumers by an indirect increase in tariff or a direct charge in bill for the same. Energy suppliers will, of course, try to push any cost they have on final customers. Consumer representatives worry that producers and energy suppliers could be the only ones taking all the benefits from deployment of smart-metering systems. If demand-response becomes compulsory there will be some low-income consumers who are already using very little energy for very basic activities and will not be able to reduce their consumption any further. Consumer activists are against the mandatory roll out of smart meters for the whole population - some consumers will pay for the smart meter all the while not being able to benefit from them. Consumers need to be given the choice on adoption of smart meters is their proposal. There should be a fair sharing of costs for all investments required, but also between all actors that could potentially benefit from the new meters: the different functionalities and benefits that they bring to different actors need to be analyzed and thus determine the distribution of costs amongst those actors.

5.1.3 Technical Challenges

Smart meter deployment includes not only the smart meters themselves, but also back-end data center hardware and software and the communications and management services required to pull stored information from each device, present usage data to the customer, transmit it back to the utility company's data centers and integrate it with existing customer relationship management (CRM) and billing systems.

Much of the discussion around smart meter specifications centers on the communications piece of the jigsaw, for which various different technologies are suitable. Wi-Fi is one candidate for the home area network (HAN), which interconnects the smart meters to in-home displays, broadband routers, communications link and other sensors at the customer location. But Wi-Fi signals do not work well inside some buildings, particularly those with thick walls and ceilings, while the 2.4GHz and 5GHz wavebands it uses are subject to interference from a range of other equipment using the same frequencies within the near vicinity. Also, Wi-Fi electricity consumption is high, meaning additional cost for the customer.

Lower power alternatives include ZigBee, a kind of slower, lower cost Bluetooth with a throughput of 250Kbit/s, which is more than enough to carry data from smart meters, and which can operate in either the 2.4GHz or 868MHz frequency band. Some suppliers are also looking.

Deployment challenges

Utilities face a broad set of challenges to confirm effective deployment of smart metering. As would be expected, European survey respondents identify an undefined business model and a lack of supporting policy/regulation as the two largest challenges to deployment (see Figure). In contrast, while some North American respondents also seem to have concerns about the degree of regulatory support, other more practical deployment considerations are also highlighted, such as data management and analytics, and lack of consumer acceptance.

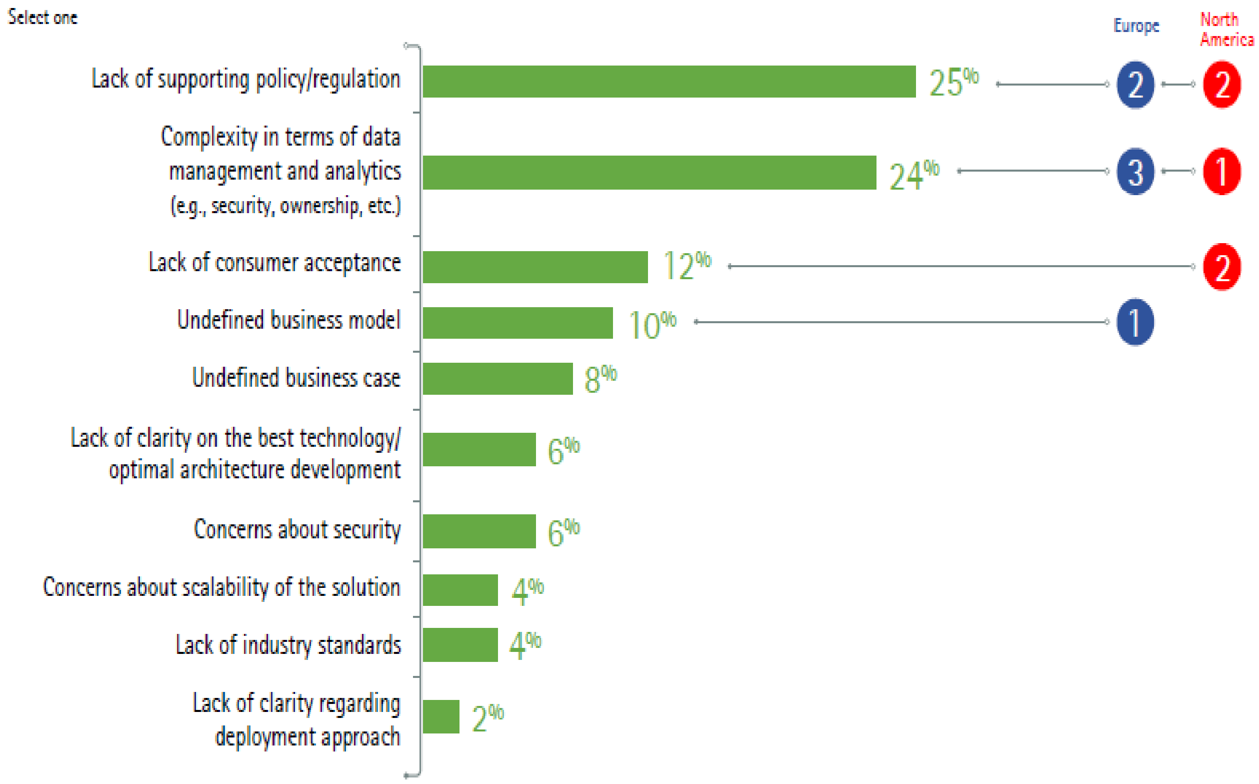


Figure 11 International Experience on Challenges to successful full-scale smart metering deployment

5.2 Recommendations

5.2.1 Moving Forward

- **Incentives to Stakeholders**

Smart meter deployment would involve huge financial investment and benefits of the project can only be accrued after deployment. With the present persistent financial state of utilities, cost effectiveness of the model is of major concern. Finances for the project can only be arranged if financers perceive profitable returns in future. So, utilities face a tight financial situation where benefits cannot precisely be measured in monetary terms. In such a situation, arranging finances for the project can be leveraged by strong government support. A project well backed by government can more easily attract investment. Smart meter deployment process can be fast tracked by government support. State governments with support from center can introduce some incentive schemes for suppliers to deploy smart meters. A strong incentive scheme to attract stakeholder‘s initiative and interest would prove helpful in facilitating smart meter deployment.

- **Enlightenment of all stakeholders**

Enlightenment of all stakeholders, consumers, utilities, investors, regulators alike, is a vital first step for the smart meter project. Only when the investing parties become aware of the benefits of the projects will they make investment. Also they must be aware of the issues of the project that may cause hindrance. Suppliers must be aware of the services they will have to provide to consumers and the regulations governing the system.

- **ToU Scheme**

The implementation of smart meters is central to the smart grid vision. Two way communications with smart meters makes sense when ToU rates are in effect. Without a means to signal the changing costs by time of day, it will not be possible to achieve the most basic of all benefits. TOU rates make good sense from an economic and business perspective, but the process of developing them, getting them approved by regulators and accepted by customers has been fraught with difficulties, and progress has been slow in India. Getting results from a valid TOU pilot is essential for the power sector – including companies, regulators and customers – to understand this concept and learn about the benefits TOU can enable.

With smart meter success riding high on ToU tariff structure, regulators need to take immediate action to successfully implement the smart meter plans. Potential sites for implementation on pilot basis should be identified to conduct a benefit analysis. Customer education and surveys can then be conducted to see response. Data from pilots can be used for mass deployment of smart meters. But all this can only be achieved with customer and political support with strong regulatory overview.

- **Regulations**

The regulatory framework needs to be properly amended in order to encourage smart metering deployment. The regulator is naturally empowered to set up the national deployment plan to decide the timing of smart meter rollout in a way that protects consumers. It would be an imperative on regulator to provide strong consumer benefits such as protecting the privacy of consumers and their energy usage data, protecting consumers from unduly rate increases caused by time-of-use pricing or other tariffs that increase energy bills when consumers use energy at times of high demand and are unable to shift their load. Regulator would also have to ensure the accuracy of smart meter data. These are some of the many responsibilities a regulator would have to supervene with smart meter system in place. India has set up high targets for smart meter deployment for the decade and with no regulations on smart metering or for that matter smart grid in place, a glitch in the project is presumably projected.

- **Consumer education**

Customer education is important as efficient and effective consumer involvement is important for success. Awareness spread among stakeholder would be an imperative on government. Consumer education however would demand a joint effort by suppliers as well. Consumer education programmes for success of ToU structure and smart meter system as whole shall have to be planned and organized well in advance of deployment. Consumers must be well aware of their rights and duties with new system in place as privacy and security concerns may bother them. Optimum benefits of the system.

- **Standards**

Standardization is the stepping stone for the project. Setting up of standards for the system equipment and services for the smart meter system would be the base of the project. Interoperability can only be achieved when the system would have standards to be followed across India by all stakeholders. Issues as equipment standardization for interoperability, consumer privacy, data security, supplier convenience, regulatory overview will all be catered by standards in place. OpenMeter is one such concept to leverage the standardization process in Europe. India may also adopt the concept to suit the home scenario. IEC standards are generally followed in India as per BIS norms.

- **Pilots**

Smart meter system benefits can only be clearly monetized and adjudged after deployment. For this purpose, pilot projects will have to be conducted to anticipate the results for mass roll out. Steps in this direction have been taken by Smart Grid Task Force but this process needs to be stepped up. Slow decision making and execution is main hurdle in all spheres in India. Smart Grids involve new technology and IT involvement which develops and transforms rapidly. A slow progress in this case would mean lagging behind global technology. So, faster pilot programmes and analysis is required for an effective system achievement.

Some recommendations:

- To encourage consumers, a reward system may be developed by the licensee to incentivize or reward the consumers who use smart meter information to reduce and/or optimize their consumption.
- Cost is a major issue so regulators should make more conducive rules to attract more private participation.
- Regulator should adopt policies to minimize technology obsolescence risk.
- For feasibility develop a web portal where consumers can get detailed information on their electric usage to enhance transparency.
- Provisions to be made in meter to notify the consumer on future energy interruptions at his/her connection point to minimize the extent of the damage resulting from an outage.
- Apart from the customer benefits the regulator should also take into account an extensive value chain, covering suppliers, metering operators, generators, etc.
- For smart metering system security different metering options can be considered as:
    - Metering infrastructure owned and operated by public utility.
    - An independent Metering Service Provider (MSP) performs metering services Metering infrastructure owned by MSP or the licensee.
    - Metering infrastructure owned and operated by the licensee.

5.2.2 Regulations

As mentioned above, regulations need to be carefully adjusted to the smart metering roll-out plans, to mitigate potential barriers to smart metering, and to create sufficient incentives for market parties to invest in and to use smart metering, thereby ensuring that prospected benefits can be realized.

For fair and transparent working of the system rational and non-discriminatory regulatory provisions are required. And this becomes even more important for smart metering implementation. Below are proposed key points to be considered by regulator for AMI.

Key points to be considered by the Regulator for Smart Metering

Data Security and Privacy issues:

- Address information, data security, privacy, interoperability and cyber security issues.
- Provisions to be made to make AMI hacking proof. Penalties and trial procedures to be set up if same is found.
- Regulations to be put in place to avoid wrong un-authorized usage of consumer information by utility or any third party.
- Update existing rules and requirements as needed.

- Broaden energy regulators mandate to consider environmental goals and don‘t let clean energies lag behind.
- See if any current regulations are at cross with carbon reduction schemes as under smart grid.
- State regulators should adopt energy efficiency resource standards with aggressive targets for cumulative savings.
- Rules how energy efficiency and conservation are measured by public utility commissions in evaluating achievements of goals and standards.
- Standardization bodies to be set for standardization of smart meters.
- Interoperability standards to be set by the regulator.

Tariff Structure

- **Time of Usage Tariff** structure found better for success of smart grids, so regulator should adopt measures for implementation of fool proof TOU tariff structure if considered.
- Regulator may also consider other new innovative pricing methods to optimize the consumption pattern of consumers. E.g.: load-dependent real-time tariff schemes.
- Regulations on current metering billing and collection (MBC) structure to be modified for implementation of smart meters and TOU tariff.
- Meter models to be made to suit information collection of different consumer groups.

- For the purpose of Net Metering the meters should measure both injected and withdrawn by the consumer.

Renewable integration and Net Metering

- Regulatory efforts in place to promote Net metering
- Tariff structure and provisions to be put in place for Net Metering in line with TOU tariff structure.
- Tariff structure should be transparent and the consumer be incentivized if he injects power during peak times.
- Renewable portfolio standards to be set.
- Study feasibility of requiring new and old residential construction to incorporate design elements to facilitate present and future adoption of renewable sources.
- Consumer assistance for deployment of renewable production models for supporting renewable integration and net metering into smart grid.
- Laws governing loan programmes for solar and wind integration.
- Provisions for risk sharing across value chain.

Consumer protection and involvement

- Specify consumer access to their energy usage data:
- Day after vs. Real time
- Historical usage
- Also retail and wholesale market prices
- Spell out rights and consumer protection for sharing data with third parties that can take advantage and exploit consumers.
- Utility can use customer information to use it against consumer in form of price discrimination. Regulator should make provision to avoid such gaming.
- Home information may be sold to burglars and advertisers by corrupt officials, so security check and information privacy issues need to be addressed by the regulator.

- Hackers can control the system, switch the meters, cut the target from grid disrupting the whole grid stability, so regulatory bodies need to make provisions to avoid such mishaps.
- Govt. may take undue advantage of the information to control the system.
- Energy Company may use data to manipulate tariffs and power availability to consumers.
- Regulatory provision regarding **Customer Education.**
- Consumers must be informed and educated on how to take advantage of new energy usage data available
- Consumer should be aware of the type of his/her usage information access the licensee has.
- With introduction of Smart Meters and Time of Use tariff structure, billing procedure may get complicated from consumer point of view. So regulatory standards and supervision must be in place for proper billing and bill standards.
- Bills issued to consumers must contain necessary information about the usage and tariff structure for the time period,
- Consumer must be aware of market rates in case of net metering.
- Incentive provision and compensation for consumers must be in place.
- Regulatory provisions to maintain transparency of the whole process of MBC.
- Consumer should benefit from newer technologies in the area of smart metering thus software up gradation should be done by the licensee for consumer and its own benefit.
- Regulator should see that the licensee does not discriminate between different consumers groups at time of smart meter roll out after operations.

Smart Meter Opt Out Policy (alternative to consumers)

Some of the model countries where smart meters have been employed have put in place a provision for consumers to opt out of smart meter systems. Studies need to be carried out if such option is feasible in Indian context or not.

Smart Meter Deployment Strategy

- **Voluntary Roll Out** based on the individual decisions of metering providers to offer smart meters to customers and to build up a smart metering infrastructure.

- **Mandatory Roll Out** An alternative approach would be a mandatory national roll-out in a given timeframe, as would be implied by the directives, if a cost-benefit analysis shows an overall positive net benefit.

Cost Transfer

The regulator has to see as to what extent the cost of smart meter deployment is transferred onto the consumer, considering the cost benefit analysis for the supplier.

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XXXIII. http://www.worldbank.org
XXXIV. http://zpryme.com/
XXXV. http://www.isgtf.in/

Annexure

1. High-level communications approach for smart meter deployment

Early awareness →

First consumer touchpoint and employee training

- Welcome letter
- Employee brochure
- Employee intranet updates
- Employees as educational advocates
- Web tutorial
- Leadership messages
- Employee feedback

New meter installation →

Community outreach and education

- Briefings with public officials and stakeholders
- Home improvement and energy-efficiency seminars
- Worksite information fairs and seminars
- Special events and venues
- Presentations at community events and neighborhood organizations
- Online resources and education

Availability of smart metering services

Consumer communication

- Website
- Actively solicit input
- Community feedback
- Consumer testimonials
- Higher-than-usual bill periods

Media outreach

- One-on-one educational briefings
- Proactive approach as part of education effort
- Emphasis on media outlets with reach into key consumer bases

Social media and advertising

- TV/radio/online/print

2. Trends in communications

Comm. network	Current position	Future trend
Wide area network (WAN)	• Strong focus on capacity planning and data prioritization to make most-effective use of limited bandwidth • Requirements for increased security of consumer data on network • Interoperability constraints with different types of FAN • Leveraging existing corporate WAN to support grid operations	• Growing importance of reliable, lower-latency networks to support real-time control • Extension of Internet protocol (IP) support to the end points in the field • Increased interest in partnerships for dedicated high-bandwidth networks
Field area network (FAN)	• Dominated by proprietary networks such as mesh radio and power line communications (PLC) • Security of consumer data supported by proprietary network • Greater importance for network reliability • Interoperability between field area networks is driving the use of IP	• More flexible networks to support different types of data traffic and allowing sharing of data with multiple applications • Leveraging of AMI technologies to support other smart grid technologies such as distribution automation • Extension to support other end points other than smart meters, such as switches, transformer sensors, etc.
Home area network (HAN)	• Limited communication beyond the meter to household smart devices • ZigBee® and Wi-Fi HAN are the dominant communication technologies	• Increasing pressure for open standards and the usage of IP as opposed to proprietary protocols • Growth of IPv6 to support increased security • Increased device control capabilities where electric vehicles or solar photovoltaic deployments become very high